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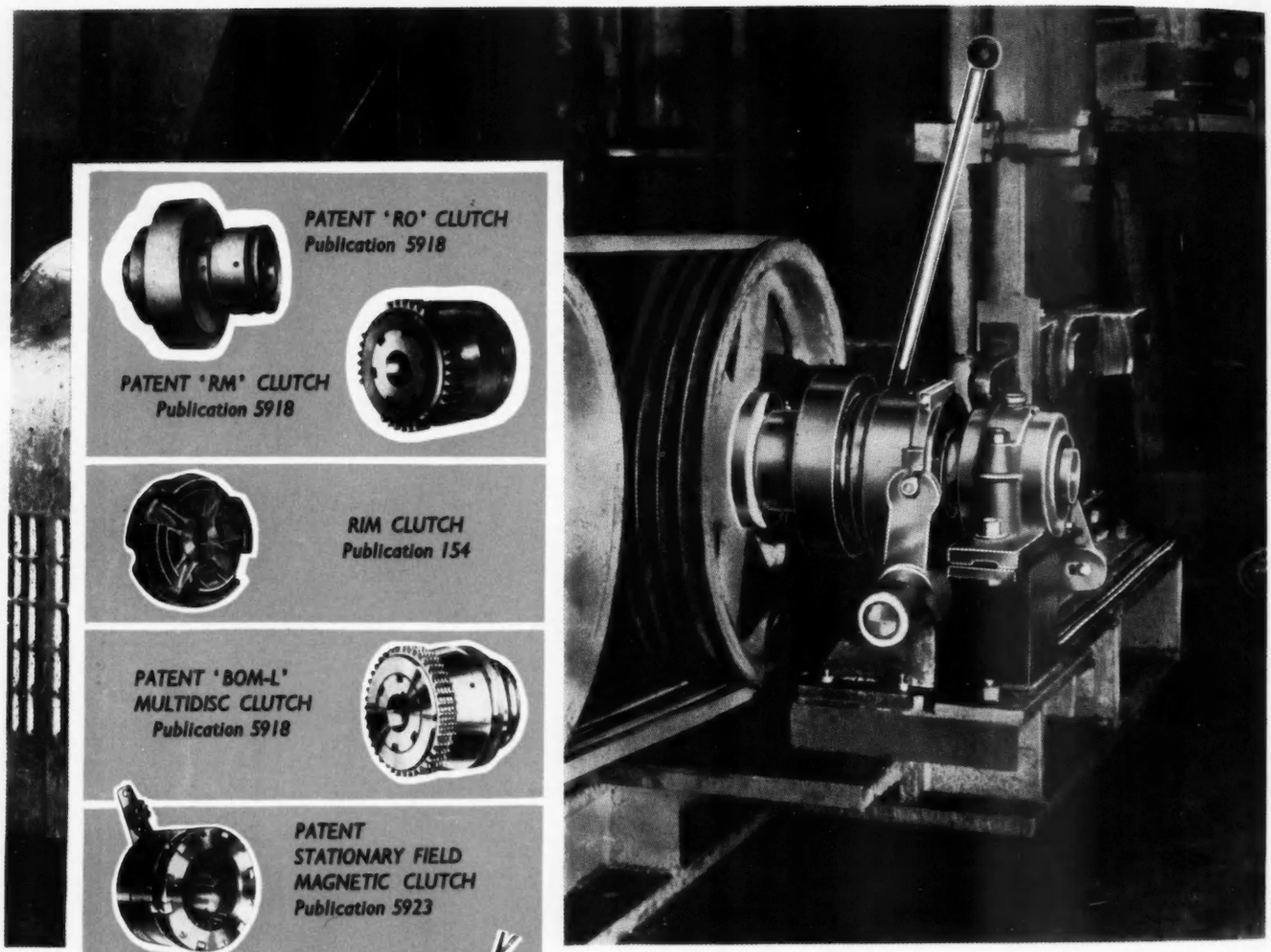

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No. 5491 **APRIL 21, 1961** VOL. 211

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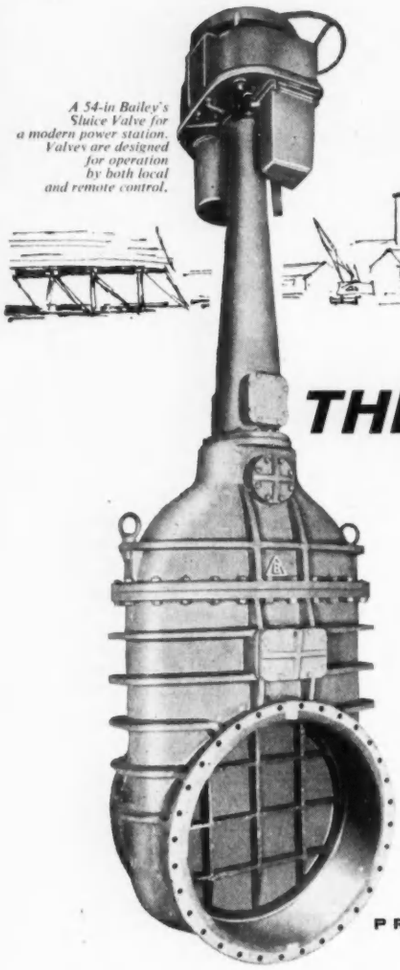

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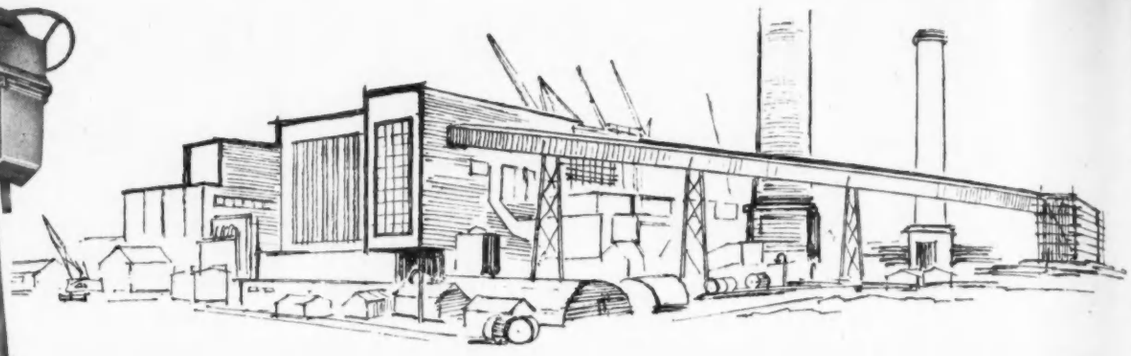

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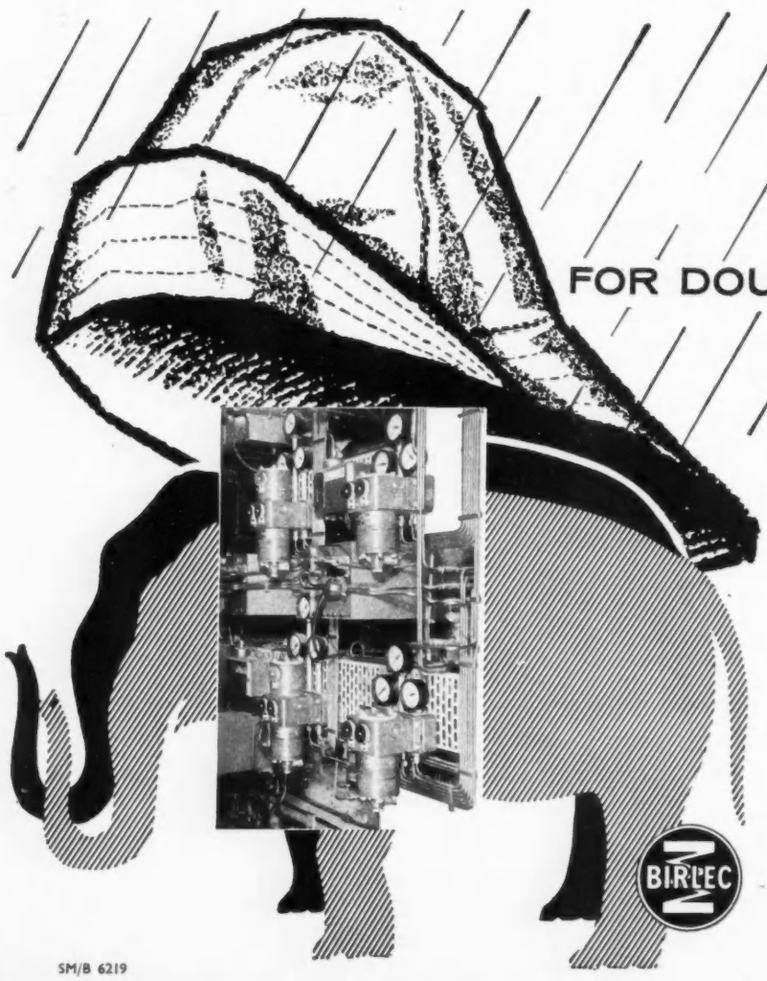

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THE ENGINEER

No. 5491 APRIL 21, 1961 Vol. 211

NEW WIND THROUGH THE TREASURY?

Judging from the nature of this year's Budget a new wind of thinking is surging through the Treasury. For un-numbered years successive Chancellors and Treasury officials have thought in terms of narrowly annual accounting. But in presenting his Budget to the House of Commons last Monday, Mr. Selwyn Lloyd said the Government was studying new methods of controlling the growth of public expenditure and that he had set in hand a study of the whole problem of public expenditure in relation to the prospective growth of resources for five years ahead. Furthermore a major proposal of the Budget is that the Chancellor should be able at any time of year to vary certain taxes and duties including Purchase Tax and the duties on tobacco, petrol and alcohol, in order to regulate the economy. The object of a proposed payroll tax is similar. But whether it would prove effective is more dubious. If the intention of levying such a tax were to be to encourage mechanisation within industry it is worth commenting that the continuous pressure from trades unions for increases in wage rates must be much more effective. If the intention were to be to encourage firms with redundant labour to discharge employees so that they could be taken on by other firms, at the time short of labour, would not so relatively small an addition to costs prove ineffective? Nor surely would such a measure prove sufficiently selective; to impose a payroll tax on the whole of industry in order to induce a few motor-car manufacturing firms, and a few other firms making what are termed consumer durables, to release labour does not sound entirely good sense.

The major proposal in the Budget is undoubtedly surtax relief. Conservatives and even some Socialists have been pressing for it for years. It was rather expected that if relief were granted this year the Chancellor would choose either to set off the allowances, including earned income allowance, against the income liable for the tax or that he would raise the starting figure. In the event he has preferred not to take two bites at the cherry and has given relief in both ways simultaneously. The benefit goes particularly to professional people. But there may eventually be a benefit for firms in that they will not have to offer such inflated salaries to attract really competent people into their employment. But some of the Chancellor's other proposals are less easy to praise. Road transport is so heavily taxed already that we find it really rather shocking that it is proposed to tax it still more! One cannot help suspecting that the proposal to increase the licence duty is intended to be a help to the railways. In fact is not any increase of transport costs inflationary? Increasing transport costs, moreover, is surely not a good method of encouraging firms to reduce export prices! In this connection it is to be noted, also, that amongst the duties the Chancellor wants to have power to vary is the petrol tax so that road transport might be asked to pay more for its fuel. No firm is likely to welcome an increase in the profits tax; but it must, we suppose, regard it as the reverse of the medal which has the reduction of surtax on its obverse side. The effect of the Budget as a whole should be deflationary as in fact some £80,000,000 of extra taxation has been imposed; however, were the economy to appear to need stimulation later in the year the power to vary certain taxes and duties would give the Chancellor the opportunity to give it a shot in the arm.

MAN IN ORBIT

In the spring of 1961 the fancies of at least some young men have turned only lightly to thoughts of love. In an exciting succession the season has seen the over-100 m.p.h. twenty-four-hour records of Velocette and of B.M.W., the first emergence of man from the atmosphere, and 10 miles run by an athlete in less than forty-eight minutes. That latter triumph differs radically from the others, and ought to bring a special honour to the young athlete concerned because it was not primarily a demonstration of the competence built up over many years by engineers and needing only man's courage and endurance to make it evident. What an engineer can do, and, particularly, how quickly he can do it is very nearly as sensitive to how much the customer is prepared to pay as to the ability of the engineer, so one can well understand that the first astronaut, Flight Major Yury Alexeyevich Gagarin, should have modestly told *Pravda* correspondents: "No, it isn't I who have performed a great feat, it is our entire Soviet people, our glorious Communist Party, the Soviet government — it is they who prepared everything for a flight into space, to make a Soviet man the first to get there."

The name of Gagarin, we confidently expect will be recorded in all history books for generations and perhaps centuries to come. But those engineers who work for less demanding masters would, of course, like to know the name of the engineer who had the moral courage to decide it was worth while to risk a man's life and also to congratulate the team of designers, producers and operators from a reasonably full knowledge of what they have achieved, and how. But unfortunately this is not yet possible. It is reported that the "spaceship" *Vostok* ("East") weighed 4·725 tonnes with crew, but excluding the last stage of the launcher, and that the orbit, inclined at 65 deg. 4 min. to the Equator, had a perigee of 108 miles and an apogee of 187 miles, corresponding to a period of 89.1 minutes. We reported last week that the duration of the flight, or fall, was 108 minutes, but the re-entry was commenced only 78 minutes after launching and occupied thirty minutes. Although it has been reported that the "space navigator" descended by parachute, he has described himself as "climbing down from the spaceship" and said that the vehicle is fit for use again — it is also reported that its radio transmissions continued after it landed — so that it can be inferred that much of its great mass is devoted to a heat sink and to braking parachutes. It is also, perhaps, noteworthy that this mass was scheduled to descend in a farming area during working hours. Apart from this, little or

nothing is known of the objective details of the flight.

Unique and unpredictable, however, are the subjective reports of Major Gagarin. In an interview with a *Tass* correspondent, he stressed that he had no feeling of isolation in space: "I was sure that the Party and Government would always be ready to help me if I found myself in difficulties." He also observed that the atmosphere appears blue even when viewed from without:

"I would say that the picture of the horizon is a most strange one and it is very beautiful. You can see a most impressive transition from the bright surface of the Earth to the completely black sky in which you can see the stars. This range of transition is a very thin one — a kind of film, a narrow belt girdling the globe. It is of a soft light blue colour and the entire transition from blue to black is most smooth and beautiful. . . . When I emerged from the Earth's shadow, the horizon seemed different. It had a bright orange strip, which then resolved itself into blue and again into pitch-black." Of his own performance he reported most encouragingly: "I have become convinced that weightlessness does not at all affect a man's fitness for work" and "my handwriting did not change."

ENGINEERS AND THE COMMONWEALTH

It is curious how every now and then the apparently unconnected events of a few days are all shown to be, in fact, related and are all brought into sharper focus by some other event which has no direct connection with any of them. That happened for us last Thursday in the Great Hall of the Institution of Civil Engineers as H.R.H. The Duke of Edinburgh delivered the seventh Graham Clark lecture, parts of which we reprint on page 652 of this issue. It reminded us that on the previous Tuesday we had attended the annual dinner of the Federation of British Industries Overseas Scholars. Prince Philip's subject was "The Engineer in Commonwealth Development." He stressed in the course of it the need not only to give aid to the more backward countries of the Commonwealth by supplying technological knowledge but also by educating and training engineers from these countries. Last Tuesday at dinner we sat beside some of those engineers under training and we conversed, amongst others, with an enthusiastic young man from Uganda, and engineers who have come to this country from South America besides the Commonwealth. They come to this country for varying periods and with a variety of aims; but all are specially selected as men of outstanding ability and promise in their own countries. We were reminded, too, by Prince Philip's address that on the Friday of the previous week the Leonardo da Vinci lectures had been delivered at the Institution of Mechanical Engineers. Prince Philip stressed that in the view of many people in this country too few engineers are being trained by comparison with the numbers being trained in other countries. He added that if we in this country were short of engineers how much shorter must less well developed countries be! He stressed the backwardness of many of the Commonwealth countries in food production, energy production, and basic industries in relation to land area and population. The Leonardo Lectures are intended for school children and there is no suggestion of propaganda about them. But the underlying idea is to interest boys and girls in engineering in the hope that a greater proportion of them will opt when the times comes for a technological career. This year, under the chairmanship of Dr. D. L. Pratt, Dr. G. S. Hislop and Mr. David Keith-Lucas spoke about and demonstrated with ingenious models the problems of vertical take-off.

Prince Philip also himself drew attention to a subject close at this time to his heart of which some account has already appeared in our pages, the Commonwealth Technical Training Week. It is to be held throughout the Commonwealth as May ends and June begins and it is being organised in this country by the City and Guilds of London Institute. "There has been a most encouraging response . . . and we hope very much that the week's activities will attract the attention of young people, their parents and employers to the need for technically trained people and to the ways and means of getting that training." But Prince Philip's main purpose in the lecture was to stress the human side of engineering. This note was sounded early in the lecture. "All large-scale projects and modernisation plans are bound to have a profound and lasting influence upon the lives of very great numbers of people. Unless their conception, execution and running are all based on a practical humanity they will contribute very little to man's progress. That is why technological training must be combined with a broad general education." The same note was sounded again and again. Almost the concluding words of the lecture were "I keep harping on the need for engineers to be educated as well as trained because I don't believe that specialist training necessarily affects those characteristics of the human mind which are needed for human administration. The qualities of imagination, enthusiasm and compassion are present to a greater or lesser extent in all of us, but it needs the process of a general and liberal education to give them point and direction." Repeatedly over the last century or so we have been making much the same point.

WHAT ARE WE TALKING ABOUT?

G. M. Young has written "Really there are times when I feel that civilisation will come to an end because no one will understand what anyone else is saying." To some extent this is not simply a pessimistic reflection on the progress of the human race. There is a measure of truth in it. Science and technology have progressed at such a rate in the last few decades—and the rate is accelerating—that nobody can understand more than a small part of what is happening. Man's individual mental capacity is limited; that appears to be one of the few unchanging facts in a changing world. Complication will increase, inevitably, with scientific development. We could not stop it, even if we would. So with ever-increasing complexity, which is unlikely to be matched by an increase in man's ability to absorb facts, it would, indeed, seem that we might reach a stage where nobody could understand anyone else. Already we are in a position where the former broad divisions of engineering —civil, mechanical and electrical—have had to be subdivided, in some cases many times, and the specialist is supreme in his field. This might not matter very much if there was no need for communication between the specialist groups. But the reverse is the case. It is ever becoming more important that specialists should communicate with each other. It is also increasingly important that all of them should be able to tell the public what they are doing.

If everybody talks his own specialised professional language—the jargon of his trade—what hope is there of anybody else understanding him? Jargon we must have, but we can do two things to keep it under control.

We can stop creating new words unnecessarily, and when it is essential to devise a new term, we can see that it is a good and logical one. As a corollary to the second proposition, we can do our best to see that if a technical word does get abroad, then at least a proper explanation goes with it. Misuse and misunderstanding of technical terms goes back a long way. Every engineer knows the meaning of horsepower, a term invented in the eighteenth century. But it has been so widely misused that it would not be an exaggeration to say that there are people who believe that the engine of a "20 h.p." car could be effectively replaced by twenty horses. Coming nearer to our time, we can all think of technical terms the meanings of which have been distorted, or even lost altogether. *Productivity*, a popular word not so long ago, was often confused with *production* and *efficient* has been made to deputise for *effective*. Today one of the villains of the piece is *automation*, which is more often than not used when *mechanisation* is meant; and by people who ought to know better, too.

Just now we have a need for a new technical term, but we were apparently, ready for that one, for we have suddenly acquired the words *astronaut* and *cosmonaut;* both, be it noted, to describe the same activity. And, of course, the science fiction writers have for years had their *space man*. One of these terms (or perhaps another one, not yet coined) is the best. Which one? We do not know, but we should make up our minds. It is probably too late to do anything about the older scientific words which have gained currency (or have run riot—according to our personal viewpoint). Some of them will die (of overwork), anyway. But we ought to try and keep the new ones under control. Science is going to demand quite a lot of them it seems, in the future, and these could, at least, be started off properly. Some co-ordinating authority appears necessary; perhaps the Minister of Science could take the matter under his wing?

WHO USES THE INSTRUMENTS?

It is fundamental to most control systems that they lend themselves to instrumentation, and up to a point it is well that they do. There are many things happening in all kinds of complicated processes which an operator cannot possibly detect with his physical senses, and there are many more which he may well detect but certainly could not measure or evaluate. Things may happen too fast, too far away, or in some situation where they are invisible to the operator. They may be of a kind which would be harmful to a human being, who must, perforce, remain at a safe distance. Several things may take place simultaneously and yet need to be observed by a single operator. It may be an essential part of a process to know what happened an hour, a day, or a week ago, as well as what is happening now; here, the recording instrument provides the answer. Even where the process is not complicated the instrument can often do the job quicker, better and more consistently than a human being could do. An old-style skilled fitter, equipped with nothing more than a pair of callipers, could probably act as quite a good comparator, but not at the speed necessary today. Moreover, being human, he is fallible, and he gets tired. An instrument, properly designed, installed and maintained, suffers from neither disability.

But if the value, and in many cases the indispensability, of instruments is beyond dispute, there is no general acceptance of how, where, and in what quantity they should be used. A cross section of industrial plants engaged on similar, or even identical, work, will disclose a remarkable lack of similarity in instrumentation and particularly in the location of the instruments. The equipment of boiler-houses, for example, will range from the simple and austere to an impressive and to some beholders, bewildering, array of dials and controls, all of which, it must be assumed, have a meaning and use. They have, of course; they all provide information needed by somebody at some time. But are they all used or needed by the person in front of whom they are placed? That is the important question. Who uses the instruments? It is a question which has been asked and answered with excellent results in some of the control layouts which are now being installed in many different fields.

Clearly an operator must be provided with sufficient instruments to tell him what he must do, when to do it, and to show him, when he has done it, that the intended result has been achieved. When instrumentation is viewed simply in that light, it sometimes results in a drastic re-arrangement of the instruments. Yet it is often found that the process operator is provided with a set of instruments which is only used by the shift engineer, the maintenance man, or someone else quite distinct in his functions from the operator. Any instrument which tells an operator something he does not need to know and could not do anything about even if he understood the indication, is more than unnecessary in that particular position. It may be vital elsewhere; it should be put there, well away from the person who does not use it and can only, if he looks at it at all, be confused as a result. This idea is growing in importance. Today there is a strong school of thought which gives each operator only the instruments he needs to do his work. It may involve having two or three instrument panels instead of one, but it makes every man's job easier and contributes a lot to the elimination of errors, to say nothing of fatigue. It is well worth while asking what every instrument is doing in a particular place, and if it cannot justify in full its existence there, putting where it ought, logically, to be.

The Engineer—100 Years Ago April 19, 1861)

"ECCLES' PATENT BRICKMAKING MACHINE"

"A most ingenious brickmaking machine, patented by Mr. J. Eccles, of Blackburn, may now be seen in actual operation at Messrs. Dray and Co.'s premises, London Bridge. The clay is taken from the embankment and placed into wagons, which run on a tramroad on a slight incline to the hopper. In the hopper are placed two sets of knives or agitators, through which the clay passes and is cut up into small pieces, preparing it for the crushing rollers; thence passing into a horizontal cylinder fitted with the ordinary pug-mill shaft and blades, working on the screw principle, and is then forced by a side knife, or wiper, through the dies on to tables fitted with rollers, where the mass is divided by wire cutters into the required size for bricks. They are then removed on trays to the drying-sheds, which are heated by steam and hot-air pipes, the former by using up the exhaust steam from the engine, and the latter by pipes inserted in the flue.

"The machine will produce 24,000 bricks in ten hours (or even much more); but 20,000 are as many as can be removed with ease. A steam engine of 12-horse power will work the whole process, with thirteen men and seven boys, to make 100,000 bricks per week."

Pressure Vessel Design Requirements in the Future*

By W. B. CARLSON, D.Sc.†

It is claimed that most of the conventional pressure vessel scantling design codes to-day are both unnecessarily restrictive and insufficiently comprehensive in their coverage. They are restrictive because all parts of the vessel are designed from one design stress which is factored to cover the worst features which might be met in any vessel. They are insufficiently comprehensive because some forms of failure are ignored. To overcome these disabilities a two-stage programme is proposed. The first stage could be undertaken now, and would be to revise the basis of the design stress and the methods of design therefrom so as to encourage good design and discourage bad. The second stage requires more comprehensive data than exist now, and would comprise design direct from physical data rather than design stress.

FOR those who are not familiar with the Pressure Vessels Commission of the International Institute of Welding (I.I.W.) it may be useful to give a brief description of its current activities. First let it be said that the I.I.W.–P.V.C. is not a code-making body and does not itself aim at drafting mandatory standards. Its purpose is to make available to designers, manufacturers, users, and to code-making bodies, the best technical information which can result from international discussion and co-operation in this field. If in a subsequent part of this paper the outlines of possible future codes are presented, this is done on the author's sole responsibility. It is also done in the belief that a forecast of design methods of the future would constitute a guide to the technical and experimental development requirements of to-day.

The P.V.C. originated at the I.I.W. Paris General Meeting of 1950 as a working group of Commission II : " Arc Welding." At Oxford in 1951 it was transferred, still as a working group, to Commission XV : " Fundamentals of Design and Fabrication for Welding," and at Florence in 1954 it became a full Commission No. XI with the title : " Pressure Vessels, Boilers and Pipe Lines." The word " Boilers " infers only " Boiler Drums," and the Commission concerns itself solely with pressure vessels and pressure parts.

The current subjects under discussion in the Commission are the following :

1. Drumhead shape delimitation.
2. Recommended weld details for pipes.
3. Weld details for deep-penetration electrodes.
4. Nozzle stressing and performance.
5. Proposals for clad and lined vessels.
6. A rational design procedure for pressure vessels.
7. Stress evaluation.
8. Stress relieving.
9. Non-destructive testing.

Where appropriate these studies, as applied to pressure vessels, are pursued in close co-operation with other I.I.W. Commissions dealing with the same subjects in a broader context. The objective is to reach an international viewpoint if possible on what is good practice, without committing anyone to its adoption.

The purpose of the present paper is to deal at greater length with Item 6—to draw attention to alternative procedures which might be adopted towards economic design, and to review the information which would be required. While it is probable that the present-day simple forms of design code, based on conventional design stresses, will remain in use for some time to come, particularly for the routine design of vessels for well-known duties, nevertheless this fact does not preclude the formulation of more sophisticated codes intended :

(*a*) to bring about the more economic design of very costly vessels where a greater engineering design effort is worth while, and

(*b*) to cater for designs and operating conditions which at present fall outside established codes.

It is recognised that considerable investigational effort and experience may be needed before some of these proposals can be realised.

1. Present Code Procedure

Before dealing with proposed revisions of code procedure, we may remind ourselves of the general principles used in most codes of to-day for the calculation of pressure part scantlings. These may be described with the aid of Table I. The philosophy of these codes is generally along the following lines.

(*a*) *Material Properties.*—For the materials for which the code is applicable, the minimum probability values of some or all of the following physical properties are enumerated against temperature : 0·2 per cent proof stress ; ultimate tensile strength ; creep stress for 1 per cent elongation in, say, 10^5 hours ; creep rupture stress for rupture in, say, $1·5 \times 10^5$ hours. It is notable that this is a restricted list of physical properties in comparison with those which might affect the performance of a pressure vessel.

(*b*) *Factor of Safety.*—To the temperature-dependent values of the above physical properties " factors of safety " are applied to reduce them to workable stresses. In practice the factors are usually of the following order :

0·22–0·33 on the U.T.S. ;
0·50–0·70 on the proof stress ;
Up to 1·00 on the creep and rupture stresses.

The factors applied to the creep and rupture stress will of course depend upon the values of the elongation and time associated therewith.

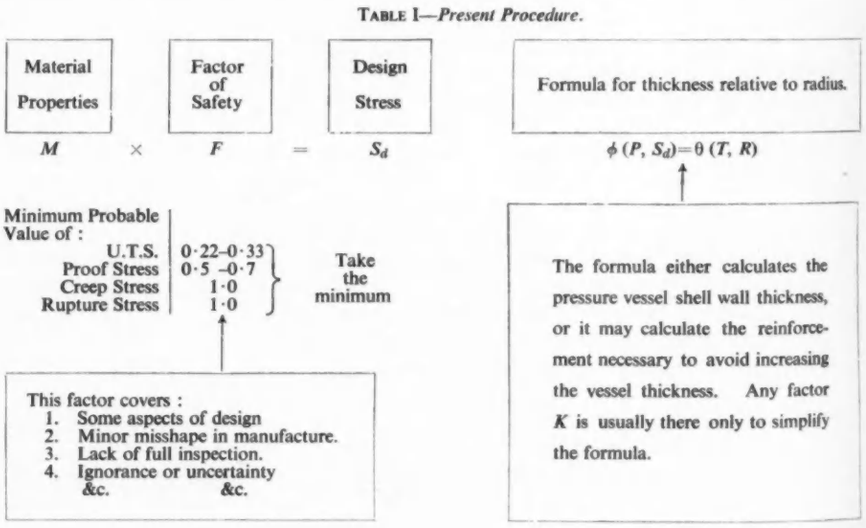
The term " factor of safety " is a misnomer, because this factor's function is to cover a wide variety of possible contingencies as under. Some of these, to put it bluntly, are plain bad features of design which, by use and wont from early days, have become accepted as liable to occur in pressure vessels :

1. Some aspects of design, such as small unreinforced holes and sharp changes in section.
2. Minor misshape in manufacture such as non-circularity, undressed welds and undercutting.
3. Lack of full inspection such as partial X-ray.
4. A feeling of ignorance or uncertainty.

The acceptance of large " factors of safety " for deriving design stress encourages the automatic acceptance of the inevitability of inferior design, which, in the author's view, is a defect which should be eliminated from future codes.

(*c*) *Design Stress.*—Having applied " factors of safety " to the selected physical properties of the material, the design stress at any temperature is taken as the minimum product at that temperature. This procedure is logical in itself, but it leaves the resultant design stress dependent upon perhaps too few physical properties and too large " factors of safety."

Table I—*Present Procedure.*


Material Properties
Factor of Safety
Design Stress
Formula for thickness relative to radius.
M × F = Sd
φ (P, Sd) = θ (T, R)
Minimum Probable Value of :
U.T.S. 0·22–0·33
Proof Stress 0·5 –0·7
Creep Stress 1·0
Rupture Stress 1·0
Take the minimum
This factor covers :
1. Some aspects of design
2. Minor misshape in manufacture.
3. Lack of full inspection.
4. Ignorance or uncertainty
&c. &c.
The formula either calculates the pressure vessel shell wall thickness, or it may calculate the reinforcement necessary to avoid increasing the vessel thickness. Any factor K is usually there only to simplify the formula.

(*d*) *Component Formulae.*—Most codes present design formulae for particular geometries of component, into which the design stress for the desired temperature is inserted. For some geometries such as drumheads and tube plates, the formula calculates the thickness of the plate forming the component. For others such as nozzles the formula may sometimes give the dimensions of the reinforcement to be added. The formula may be fundamental or empirical, the aim being to

* Paper presented to the American Welding Society, New York, April 19.

† Chief research engineer, Babcox and Wilcox, Ltd., London.

cling to extreme simplicity. It may contain an empirical factor K which in most cases merely simplifies an otherwise complex geometric formula, but occasionally may take some cognisance of an environmental condition such as corrosion or entry into the creep range of temperature. The latter functions of K are very limited in their scope in existing codes.

2. Shortcomings of Present Codes

From the foregoing description it is evident that the relatively simple forms of code in use to-day tend to take cognisance of too few facts. As a consequence they are inclined to err on the safe side to the detriment of economy.

The undernoted physical properties, which are of sometime interest to every designer, are among those which are not taken into account in determining design stress :

High-strain-fatigue strain range ; corrosion-fatigue strain range ; stress-corrosion-cracking stress ; fast-fracture-initiation stress ; stress-relaxation creep strain ; short-term ductility ; elastic properties.

It is of course a fact that materials are chosen bearing certain of these properties in mind ; moreover it may be technically inappropriate to attempt to introduce them into the procedure for determining design stress. However, it is also true that few present-day formulae for the design of components embody any parameter which recognises the type of failure against which the component is to be designed.

The design stress, as derived by the method described under sections 1 (*b*) and (*c*) above, is left to cater for all types of failure, which may be liable to occur in different proportions in various vessels. Its success to date is clear proof that it must be highly extravagant in some instances.

3. Possible Alternative Procedures

Two possible alternatives to present-day code procedures are envisaged. The first could reasonably be negotiated now by code-making bodies. The second is something to which we might look forward in the future, when sufficient data and experience have been systematically accumulated.

The first proposal aims at raising the "tabulated temperature dependent design stress" to the highest value which would be usable in an idealised vessel under ideal operating conditions. The design formula for any particular component would then be devised so as to take due account of both shape-departures and operating-departures from the ideal. Thus the philosophy of this proposal is that we should start with the highest possible design stress and modify it downwards as necessary, rather than starting with an excessively safe stress and tolerating the poor design features which it permits.

The second proposal aims at removing the "design-stress" concept altogether from codes, and designing against each contingency of failure by starting from the basic material properties which control such failures. This is an ambitious project for the future, demanding the accumulation of much data and experience which is presently lacking. It is included here mainly with the object of giving some concerted general direction to those who are willing and able to pursue investigations in this field.

4. First Amended Procedure Proposal

Vessels for the same duty are thinner in some countries than in others, largely because more favourable "factors of safety" are used in converting physical properties into design stresses. In other words good field experience has been followed by larger or more frequent adjustments of these arbitrary and empirical factors.

Another, and seemingly superior, approach to the problem would be to establish the upper limit for the design stress under ideal conditions, and to work backwards from this for each departure from the ideal. To this end suppose we define an "Idealised Pressure Containment Project" as being one in which:

1. The vessel is composed of one pure geometric shape, such as a thin sphere or an infinitely long thin cylinder, having only pure membrane stressing with no deliberate or accidental stress intensifications ; and

2. The conditions of operation comprise only steady internal pressure at constant temperature, with no corrosive media present and no limitations on elastic inflation with pressure.

Then, under these ideal conditions, there would be no reason why the membrane stress should not be 99 per cent of a suitable minimum probability value of the yield, or creep, or rupture stress of the material at the working temperature, provided also that the material had a reasonable ratio of yield to U.T.S. so as to ensure an adequate margin between yield and burst. Thus the above formulae would recognise component shape and loading. They would also recognise an approximate general relationship between the design stress and the specified mode of duty failure against which the component is to be designed, by the use of empirical factors K in the formulae.

The third aspect would be catered for by the application of a manufacturing departure factor d where appropriate.

This first amended proposal would constitute a major step towards breaking away from the stultifying effects of basing the designs of all components on a design stress incorporating a large arbitrary "factor of safety." The detailed implementation of this proposal for component design would require to be worked out, but the general lines on which it might operate are suggested in an Appendix.‡

This proposal, like any other which may be made in the absence of complete technical information on the behaviour of pressure vessels, is subject to the criticism that it must inevitably depend on the use of certain practically determined factors. Its virtue is claimed to be in the use of separately determined factors in separate situations, thus bringing individual component scantlings nearer to their minimum permissible values.

Table II—*First Amended Procedure Proposal.*

Material Properties	Design Stress	Formula for thickness relative to radius.
	$M = S_d$	$\phi(K, d, P, S_d) = \theta(T, R)$
Minimum probable valve of : Proof Stress Creep Stress Rupture Stress		
The design stress is that stress which might be applied in conditions of idealised membrane stressing under steady load and temperature with no complications.		The formula calculates shell thickness or the thickness for a reinforcement, taking account of the appropriate critical criterion of failure with the aid of a factor K. The formula also allows for varying tolerances on the component geometry through a manufacturing departure factor d.

mentioned minimum probability value could become the basic design stress used in the first amended procedure code. The general philosophy of such a code would be that illustrated in Table II.

(*a*) *Design Stress.*—The design stress at any temperature would be equal to the lowest of the minimum probability values of the 0·2 per cent proof stress, the creep stress for 1 per cent elongation in, say, 10^5 hours, and the creep-rupture stress for rupture in, say, $1{\cdot}5 \times 10^5$ hours. There would also be a limit on the maximum proportion of proof stress to U.T.S. There would be no "factors of safety" standing between the above physical properties and the design stress.

(*b*) *Component Formulae.*—The formulae for calculating component wall thickness or reinforcement would take account of three things :

1. The presence and distribution of stress intensifications due to the designed shape-departure of the component from pure thin sphere or cylinder.

2. The possibility of there developing in the component modes of failure other than full-wall-thickness yield.

3. The presence of manufacturing tolerances which might have appreciable effect on the stress system and the performance of the component.

The first two of these aspects would be catered for as follows. The component

5. Second Amended Procedure Proposal

This proposal recognises the fact that it is illogical to base design procedures aimed against a variety of failure contingencies on the use of a single "design stress." Design against fatigue, stress corrosion, brittle fracture, or against elastic deformation, all demand the use of material properties which are not taken into direct account in the derivation of a single "design stress." They may be allowed for indirectly by the method of the "First Amended Procedure" as suggested in Appendix I. A superior method would be to accumulate adequate material property data, and to use this directly in formulae designed to cater for each failure contingency or criterion.

The philosophy of the second proposal is summarised in Table III and a list of failure contingencies, critical criteria and material properties is given in Table IV, which may be regarded as fairly comprehensive.

Much data is needed to enable this proposal to be put into effect. Nevertheless it is pleasing to be able to report that the I.I.W. Pressure Vessels Commission has made a systematic start on the problem. Towards this end it invited the delegations of several countries each to write a first draft thesis on

‡ Not reproduced here—Ed., The E.

TABLE III—*Second Amended Procedure Proposal.*

Material Properties	Formula for thickness relative to radius.
M	$\phi(d, P, M)=\theta(T, R)$
Minimum or maximum probable values of all stress properties, and all elastic and plastic strain properties, are tabulated against temperature and used directly for scantling design.	The formula uses the appropriate physical property M directly so as to design against the critical criterion of failure which is operative. It thus calculates shell thickness or reinforcement without the need for a factor other than the manufacturing departure factor d.

TABLE IV—*List of Failure Contingencies, Critical Criteria and Material Properties.*

Failure Contingency	Critical Criteria
1. Excessive Plastic Deformation.	
(*a*) Short-term (on loading)	First yield.
1. Uniform *F-W-T* deformation.	Change of shape *per se*.
2. Non-uniform deformation.	Trouble at non-integral joints.
(*b*) Long-term (creep).	Low-elongation cracking.
1. Uniform *F-W-T* deformation.	Plastic instability.
2. Non-uniform deformation.	
2. Excessive Elastic Deformation.	Change of shape *per se*. Maldistribution of loads. Trouble at non-integral joints. Elastic instability.
3. High-strain Fatigue.	Fatigue cracking.
4. Corrosion Fatigue.	Corrosion fatigue cracking.
5. Stress Corrosion.	Stress corrosion cracking.
6. Brittle Fracture.	Low-stress fracture initiation.

Material properties invoked

1. Proof Stress, Elongation, R.A., Creep Stress, Creep and Relaxation Strain, Rupture Stress and Ductility.
2. Modulus of Elasticity, Poisson's ratio.
3. Fatigue Strain range for failure in " N " cycles.
4. Corrosion Fatigue range for failure in " N " cycles.
5. Stress Corrosion Stress for Cracking in " t " hours.
6. Low-Stress Fracture Initiation conditions.

designing against one of the Table IV failure contingencies. So far initial theses have been forthcoming as follows : Brittle Fracture, U.K. ; High Strain Fatigue, U.S.A. ; Stress Corrosion, France ; Excessive Plastic Deformation, Netherlands.

The objective has been to pin-point the state of the art in these fields as applied to pressure vessels. Each thesis should itself form a guide to the work still required, and should be periodically brought up to date. It is not claimed that the approach is novel, but it is aimed at being fairly comprehensive.

APPENDIX I

SCANTLING CALCULATIONS ON FIRST AMENDED PROCEDURE PROPOSAL

Starting with the " Idealised Pressure Containment Project " defined in Section 4 of the paper, the methods of calculating a thin sphere and an infinitely long thin cylinder respectively would be :

$$T/R=P/2S_d \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and :

$$T/R=P/S_d \quad . \quad . \quad . \quad . \quad . \quad (2)$$

respectively, where :

T=Thickness
R=Radius
P=Pressure
S_d=Design stress on the first amended procedure basis.

Departures from the ideal may be of three general forms as already explained, namely :

1. in the designed shape, such as making the vessel thick ; putting an end closure on a cylinder ; putting a hole or a nozzle into the vessel, &c ;

2. catering for failure other than by uniform full-wall-thickness yield, such as putting a limit on elastic strain ; putting a limit on short-term plastic deformation ; or avoiding high-strain fatigue, corrosion fatigue, stress corrosion, brittle fracture, &c ;

3. allowing for manufacturing tolerances.

To cater for any of these departures from the ideal, the generalised design equation for sphere and cylinder may be written :

$$\theta(T, R)=\phi(K, d, P, S_d) \quad . \quad . \quad . \quad . \quad (3)$$

where :

θ, ϕ=Functions catering for the intended forms of geometry ;
K=A factor catering for various forms of failure against which the vessel is to be designed ;
d=A departure factor catering for the fact that manufacturing tolerances permit components to depart from the designed shape.

One of the complications of pressure vessel design is that the above forms of departure from the ideal cannot each be treated separately in generalised form. By this it is meant that, generally speaking, it is necessary to specify the particular geometry before considering the effects of the type of failure against which the design process is to guard. Thus it is now necessary to consider particular geometries in order to illustrate the use of K in designing against particular failure contingencies. It is also necessary to bear in mind that the " First Amended Procedure Proposal," with which we are presently concerned, is one which is still based on the use of a " design stress " as the primary starting point in the design process. All formulae must therefore incorporate this quantity.

In order to simplify the following illustrations, the factor d will be assumed unity. This in no way prevents it being given an appropriate value in a practical case, because it is a straight multiplier to factor K.

Starting with the most usual simple geometry let us consider :

(*a*) *Thin Cylinders* (*Open Ended*).—We have already noted that under idealised pressure containment conditions, design would proceed in accordance with Equation (2). If, however, a limit were imposed on the maximum elastic strain permitted in the vessel so as to avoid, for example, distortion of a mechanical joint, then :

$PR/T=E\varepsilon$, where E=Young's modulus, ε=Strain

$$T/R=P/E\varepsilon=(S_d)\,P/(E\varepsilon)\;S_d=P/KS_d \quad . \quad . \quad (4)$$

Thus vessels normally designed to a stress of say 30,000 lb per square inch (amended basis), but requiring a strain limitation of say 0·00025in/in, would require K=0·25, and the design formula would become :

$$T/R=P/0{\cdot}25S_d \quad . \quad . \quad . \quad . \quad (5)$$

making the vessel four times thicker than purely stress considerations would demand.

This simple example illustrates one of the absurdities of designing solely from a design stress, and one of the reasons why we should ultimately aim at the " Second Amended Procedure Proposal."

Suppose next that the thin cylinder is required to withstand an appreciable number of pressure fatigue cycles and that the appropriate limiting fatigue stress range is Sf. The direct approach would be to use :

$$T/R=P/S_f \quad . \quad . \quad . \quad . \quad . \quad (6)$$

but under the " First Amended Procedure " this equation would be written :

$$T/R=(S_d/S_f)\,(P/S_d)=P/KS_d \quad . \quad . \quad (7)$$

In other words the fatigue criterion would be related to ideal design conditions by means of a factor K, which might have been determined on a related component or specimen at design temperature but not necessarily on the particular component being currently designed.

(*b*) *Thick Cylinders* (*Open Ended*).—These represent a departure from the ideal in respect of geometry, but if the form of failure against which design is to proceed is full-wall-thickness yielding on either short or long term, then Equation (2) with R interpreted as the mean radius can be shown to be adequate.

If a limit is to be imposed on maximum elastic strain, then of course elastic equations must be used :

$$P\left[\frac{R_0^2+R_i^2}{R_0^2-R_i^2}+\nu\right]=E\varepsilon_i$$

$$P\left[\frac{2\,R_i^2}{R_0^2-R_i^2}\right]=E\varepsilon_0$$

R_0=Outside radius
R_i=Inside radius

whence :

$$\left[\frac{R_0^2+R_i^2}{R_0^2-R_i^2}+\nu\right]^{-1}=\frac{P}{E\varepsilon_i}=\left(\frac{S_d}{E\varepsilon_i}\right)\frac{P}{S_d}=\frac{I}{K}\cdot\frac{P}{S_d} \quad . \quad . \quad (8)$$

$$\left[\frac{2R_i^2}{R_0^2-R_i^2}\right]^{-1}=\left(\frac{S_d}{E\varepsilon_0}\right)\frac{P}{S_d}=\frac{I}{K}\cdot\frac{P}{S_d} \quad . \quad (9)$$

These equations are directly comparable with Equation (4) which represents the thin cylinder case.

To design a thick cylinder against fatigue is not at the moment a straightforward case[1] and is here left to the specialist.

(*c*) *Drumhead on Thin Cylinder*.—This combination is a departure from the ideal in

respect of geometry, with possibly the single exception of the hemispherical head of half the thickness of the shell. Even in this case there is a thickness transition. In general there are incompatibility forces and moments between cylinder and head, which make it impracticable to design against uniform full-wall-thickness yielding. Thus there must also be a departure from the ideal in respect of the design criterion, even for design against excessive short-term plastic deformation.

The bulk of both theoretical and experimental data for drumheads is concerned with elastic stress distributions. Very little data exists for drumheads under elastic-plastic or fully plastic conditions. Perhaps the most promising method for design of very thin drumheads against excessive short-term plastic deformation is to base on the limit pressure obtained by the methods of limit analysis. Shield and Drucker[2] have obtained the limit pressures for A.S.M.E. standard heads in the range $T/R=0{\cdot}008$ to $0{\cdot}028$ for the particular case of crown radius equal to cylinder radius. Their results can be used for the design of such A.S.M.E. heads against excessive short-term plastic deformation, and could usefully be extended to other drumhead geometries.

If, however, available elastic solutions have to be used as an intermediate measure for design against excessive short-term plastic deformation, then it is well-known that it would in general be too conservative to design against the onset of theoretical yield. Instead some advantage can be claimed for the constrained nature of the system and the well-known redistribution of stress after the first application of pressure to the vessel. According to simple theory this should permit the maximum stress to reach twice the design stress S_d (amended basis), but it is more usual to use $1<K<2$ depending on the constraint of the system and the local yield behaviour. Thus :

$$\frac{T}{R}=\frac{(\text{SIF})}{K}\cdot\frac{P}{S_d}=\frac{(\text{SIF})\,P}{1{\cdot}7S_d} \quad . \quad . \quad . \quad (10)$$

where :

(SIF)=Elastic stress intensification factor of the head referred to the hoop stress in the cylinder ;

R=Cylinder radius.

If a limit is to be imposed on maximum elastic strain, for instance to limit deformation at a manhole opening, equations on the same principles as Equation (4) may be formulated.

If we have to design against a limiting fatigue stress range of S_f then the equation becomes :

$$\frac{T}{R}=(\text{SIF})\left(\frac{S_d}{S_f}\right)\cdot\frac{P}{S_d}=\frac{(\text{SIF})\,P}{K\;S_d} \quad . \quad (11)$$

on similar lines to Equation (7).

(*d*) *Nozzle in Thin Sphere.*—Like the drumhead dealt with under section (*c*) this combination is a departure from the ideal in respect of geometry. This being so, it is also impracticable to design the combination against full-wall-thickness yielding, and thus there is also a departure in respect of the design criterion. In point of fact practicable nozzle-in-shell design to-day still rests on the use of elastic solutions. Thus to design against :

1. Excessive short-term plastic deformation we use Equation (10) ;
2. Excessive elastic deformation we use an equation on the same principle as (4), and
3. Fatigue we use Equation (11),

where in all cases T/R refers to the main shell, and the stress intensification factor responds to the other key dimensions and is related to the undisturbed shell stress ; also where K depends on the degree of constraint and local yield behaviour of the system, and may reach $1{\cdot}7$ for nozzles in spheres, subject to checking for very thin spheres.

Good elastic solutions are available for radial nozzles in spheres, and it is possible that many cases of non-radial nozzles in spheres, and nozzles in cylinders, can be treated by adjustment thereto.

Sufficient has been given above to illustrate the principles of the " First Amended Procedure Proposal." These ideas are summarised in Table V. It is the province of code-making bodies to decide whether these proposals should be detailed and carried into effect. Sample calculations on a nozzle problem are given in Appendix II.

TABLE V—*Formulae for Internal Pressure Loading.*

Design Against	Thin Cylinder (Open Ended)	Thin Sphere	Thick Cylinder (Open Ended)	Drumhead on Thin Cylinder	Nozzle on Thin Sphere
Excessive Short-term Plastic Deformation ...	$\frac{T}{R}=\frac{P}{S_d}$	$\frac{T}{R}=\frac{P}{2S_d}$	$\frac{T}{R}=\frac{P}{S_d}$	$\frac{T}{R}=\frac{(\text{SIF})}{1{\cdot}7}\cdot\frac{P}{S_d}=\frac{(\text{SIF})}{K}\cdot\frac{P}{S_d}$	$\frac{T}{R}=\frac{(\text{SIF})}{1{\cdot}7}\cdot\frac{P}{2S_d}=\frac{(\text{SIF})}{K}\cdot\frac{P}{2S_d}$
Excessive Long-term Creep	$\frac{T}{R}=\frac{P}{S_d}$	$\frac{T}{R}=\frac{P}{2S_d}$	$\frac{T}{R}=\frac{P}{S_d}$	?	?
Excessive Elastic Deformation	$\frac{T}{R}=\left(\frac{S_d}{E\varepsilon}\right)\frac{P}{S_d}=\frac{1}{K}\cdot\frac{P}{S_d}$	$\frac{T}{R}=\left(\frac{S_d}{E\varepsilon}\right)\cdot\frac{P}{2S_d}=\frac{1}{K}\cdot\frac{P}{2S_d}$	$\phi(R_o, R_i)=\left(\frac{S_d}{E\varepsilon}\right)\frac{P}{S_d}=\frac{1}{K}\cdot\frac{P}{S_d}$	Galletley†	?
High-strain Fatigue ...	$\frac{T}{R}=\left(\frac{S_d}{S_f}\right)\cdot\frac{P}{S_d}=\frac{1}{K}\cdot\frac{P}{S_d}$	$\frac{T}{R}=\left(\frac{S_d}{S_f}\right)\cdot\frac{P}{2S_d}=\frac{1}{K}\cdot\frac{P}{2S_d}$	Morrison Crossland and Parry*	$\frac{T}{R}=(\text{SIF})\times\left(\frac{S_d}{S_f}\right)\frac{P}{S_d}=\frac{(\text{SIF})}{K}\cdot\frac{P}{S_d}$	$\frac{T}{R}=(\text{SIF})\times\left(\frac{S_d}{S_f}\right)\frac{P}{2S_d}=\frac{(\text{SIF})}{K}\cdot\frac{P}{2S_d}$

* See Reference (1). † See Reference (3).

APPENDIX II

ILLUSTRATIVE EXAMPLE ON FIRST AMENDED PROCEDURE PROPOSAL

Consider the design of a thin spherical vessel having a radial cylindrical nozzle to comply with the following requirements :

Sphere, i.d.	800in
Nozzle, i.d.	24in
Design pressure	80 lb per square inch gauge
Design temperature...	20 deg. Fah.
Full pressure cycles in life	10,000 maximum

Non-corrosive liquid
Welded nozzle, flush on inner surface.
No added compensating pads.
Shape tolerance within $\pm 0{\cdot}5$ per cent.
Full radiography and stress relief.

Assume the material to be SA-201-A :

C	Si	Mn	P	S
0·20–0·35	0·15–0·30	0·80	0·035 max.	0·04 max.

Design stress at 20 deg. Fah.... ...	13,750 lb per square inch
Yield stress at 20 deg. Fah.	29,000 lb per square inch

PRESENT PROCEDURE (ASME 1959 UNIFIED PRESSURE VESSEL CODE)

$$T_s=\frac{P\,R_s}{2\,S_dE-0{\cdot}2\,P}$$

$$=\frac{80\times 400}{(2\times 13{,}750\times 1)-(0{\cdot}2\times 80)}$$

$$=1{\cdot}16\text{in}$$

$$T_n=\frac{P\,R_n}{S_dE-0{\cdot}6\,P}$$

$$=\frac{80\times 12}{(13{,}750\times 1)-(0{\cdot}6\times 80)}$$

$$=0{\cdot}07\text{in}.$$

Total cross sectional area of compensation required to be added as first approximation :

$$=1{\cdot}16\,[24+(2\times 0{\cdot}07)]=28\text{in}^2$$

From these basic quantities and the calculations for A_1 and A_2 it is found that the following typical combinations of thickness satisfy the code requirements :

T_s;T_n	1·5	1·0	0·5
T_s (in)	1·66	1·75	2·25
T_n (in)	2·50	1·75	1·13

FIRST AMENDED PROCEDURE PROPOSAL

Under the design conditions postulated, it can readily be shown that the most likely general failure contingency would be excessive short-term plastic deformation. Hence :

$$T_s=\frac{P\,R_s}{2\,S_d}$$

$$=\frac{80\times 400}{2\times 29{,}900}$$

$$=0{\cdot}535\text{in}$$

$$T_n=\frac{P\,R_n}{S_d}$$

$$=\frac{80\times 12}{29{,}900}$$

$$=0.032\text{in}$$

If these basic dimensions were used as such, then from Rose and Thompson[4] the circumferential stress intensification factor at the nozzle bore would be obtained as follows :

Replacement factor y

$$=\frac{0{\cdot}39\times 0{\cdot}032}{0{\cdot}535}\,\frac{(0{\cdot}032)^{\frac{1}{2}}}{(12)}$$

$$=0{\cdot}001$$

$$\frac{R_s}{T_s}=\frac{400}{0{\cdot}535}=750$$

$$\frac{R_n}{R_s}=\frac{12}{400}=0{\cdot}03$$

From Fig. 1.5 of the paper[4] it is seen that the maximum stress intensification factor in the shell will be :

$$(\text{SIF})=3{\cdot}0$$

that is, greater than $1{\cdot}7$.

Thus the shell thickness of 0·535in would not comply with the formula :

$$\frac{T_s}{R_s}=\frac{(\text{SIF})}{1{\cdot}7}\cdot\frac{P}{2\,S_d}$$

for nozzles in thin spheres when designing against excessive short-term plastic deformation.

Repeating the stress intensification factor

calculation using new trial values as follows :

$$T_s = 0{\cdot}0875\text{in}$$

$$T_n = 0{\cdot}5\ T_s = 0{\cdot}438\text{in}$$

it is found that :

$$(\text{SIF}) = 2{\cdot}7$$

Checking back :

$$T_s = \frac{2{\cdot}7}{1{\cdot}7} \cdot \frac{80 \times 400}{2 \times 29{,}000} = 0.85\text{in}.$$

This value could be adjusted up to say 0·86in for complete balance, but in practice the external fillet weld might provide the remaining reinforcement needed. The following typical combinations of thickness satisfy the first amended procedure theoretical calculation :

T_n/T_s	1·5	1·0	0·5
T_s (in)	0·63	0·70	0·85
T_n (in)	0·95	0·70	0·43

These values show a surprising contrast with those obtained from the code, particularly when it is remembered that the amended formula uses the relatively unfavourable factor 1·7 in place of the theoretical value of 2·0 for plastic stress adjustment.

However, it must be recalled that no factor d for manufacturing shape departure from the ideal has been incorporated. This factor should be included in the formula as follows :

$$\frac{T_s}{R_s} = d \cdot \frac{(\text{SIF})}{1{\cdot}7} \cdot \frac{P}{2\,S_d}$$

as d is a multiplier to the stress intensification factor.

A typical maximum out-of-roundness of ±0·4 per cent in a thin cylindrical shell would make $d = 1{\cdot}5$. Thus the above thicknesses could reasonably be increased by 50 per cent, giving the following practical values from the first amended procedure :

T_n/T_s	1·5	1·0	0·5
T_s (in)	0·95	1·05	1·29
T_n (in)	1·43	1·05	0·65

These values still show a remarkable reduction on the code thicknesses.

Checking the above conclusions for design against high strain fatigue, it has been found in many experiments that the measured maximum strain range to produce failure in 100,000 cycles has to be of the order of 0·2 per cent. This corresponds to a notional elastic fatigue stress of :

$$S_f = 30 \times 10^6 \times 0{\cdot}002$$

$$= 60{,}000 \text{ lb. per square inch}$$

$$\therefore K = \frac{60{,}000}{29{,}000} = 2{\cdot}0$$

which, when substituted into the formula

$$\frac{T_s}{R_s} = \frac{(\text{SIF})}{K} \cdot \frac{P}{2\,S_d}$$

will give a thinner shell than when $K = 1{\cdot}7$.

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Engineering Design

By HUGH CLAUSEN, O.B.E., I.S.O., B.Sc.(Eng.)

EFFORTS are currently being made to study design in engineering matters ; to examine the structure of the industry in respect of the standards, qualifications, and numbers of men employed in design work, and their place in the industrial hierarchy. Simultaneously, the question of teaching—or stimulating interest in—design in university engineering departments and technical colleges, and also during training within industry, is under examination.

It appears that the professional institutions, almost without exception, have lost interest in the design aspects of engineering, even although James Watt's view that design work is the highest form of activity in which a mechanical engineer can engage[1] has recently been confirmed by Dr. J. A. Hrones, vice-president for Academic Affairs, Case Institute of Technology, in his James Clayton Lecture to the Institution of Mechanical Engineers on January 5, 1960. He states categorically that : " Design in its fullest meaning is the top role of the engineer."

Discussions and papers on these matters have covered a number of aspects, and various views have been put forward, some of them with very little foundation. Anyone, whether user, spectator, expert critic, reader, or student, has a perfect right to criticise and express his views on any finished product, whether it be a poem, a film, an engineering product, a piece of memorial sculpture, a novel, or anything else. The works of the engineer, in particular, stand—as it were—on a pedestal to be shot at by all and sundry, often for a very long time. Expert knowledge or professional skill is not a prerequisite for such criticism. One does not have to be an expert tailor before criticising either the cut of a pair of trousers, or the performance of a sewing machine.

When it comes to study and criticism of methods of teaching or doing design the conditions are different. Any successful engineer will (indeed must) have developed his own methods, or hired or borrowed the requisite talents and skill from somewhere. He is likely to know something—even though possibly at second hand—about the design process. First-hand personal experience of doing design work of some kind seems however, to be a prerequisite for valid comment on, or criticism of, methods of organising or teaching it. Though methods vary widely in practice there is a mutual appreciation and understanding between actual practitioners, even though their methods be totally at variance. Such understanding seems difficult, if not impossible, between the designer and the administrator or scientist, unless the latter have a modicum of personal ability in the work involved.

This seems logical. The art critic, in his comments on paintings or sculpture may, with luck, be able to express in words something of what the artist was doing—or striving for—and comment effectively on his work. He would probably be the last man—however—to suggest to the artist how he should go about his work ; or what would be the best sort of training for him, or for others. The same applies to the salesman, dealer, or purchaser of the work. He may comment on the final result ; but the means towards achieving that end must be left to the practitioner rather than to the critic, the salesman, or the administrator. It has been well said that no man can form a really valid judgment on an activity in which he has not, at some time, personally taken some part.

This view exposes a weak joint in our educational, social, and industrial structure. Over-emphasis on the administrative and managerial aspects of British industry has pushed the creative aspects (on which everything depends) down to such a low level in the hierarchy that they can no longer be effective. This appears to be a main cause of our present export difficulties.[2] The entry of talented men into the creative fields has been heavily discouraged, with the inevitable result that there is a disproportionate—and increasing—amount of work being done under licence to foreign designs. Though some short term benefit may accrue from this, the long term result is disastrous : in further erosion of our own creative abilities.

The design structure of the engineering industry has little common basis. That of our educational establishments can hardly be said to exist at all. No two firms seem to work in quite the same way, even though their products may be similar. The only way of strengthening an industry is to increase the human ability of its creative side. The problem of attracting, to this side, men of equal calibre and ability to those on the managerial and administrative sides remains. It must be solved if we are to continue to exist as an industrial nation : and there is no other chance.

[1] Professor A. F. Burstall, Chairman's Address to North Eastern Branch of the Institution of Mechanical Engineers, October, 1956.

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Obituary

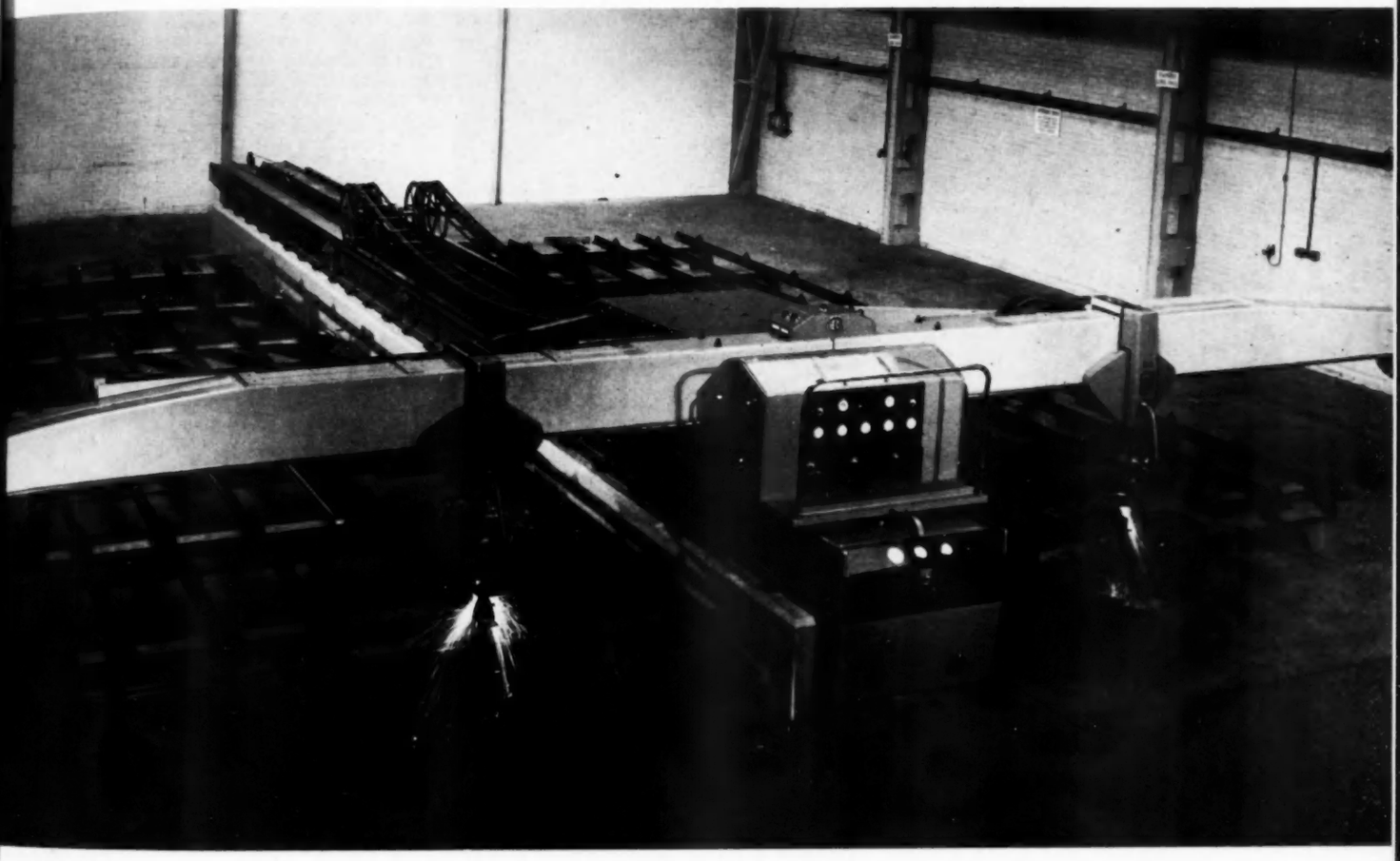
ARTHUR ARNOLD

IT is with sincere regret that we have to record the sudden death on April 6 of Mr. Arthur Arnold, A.M.I.Mech.E., A.M.I.E.E., M.I.Plant.E., F.Inst.F., the editor of *Power and Works Engineering*. Mr. Arnold, who was sixty-nine, was born at Lymington, Hants, and educated at Southampton Grammar School. He became an articled pupil first at Siemens Brothers Dynamo Works, Southampton, and then at Weymouth Corporation Electricity Works. Subsequently, he held posts as charge engineer with Weymouth Corporation, Watford Electricity Works, North Metropolitan Electric Power Supply Company, Walthamstow U.D.C., County of London Electric Supply Company, Luton Corporation, and Yorkshire Electric Power Company. He also worked for a time in the turbine shops of Richardsons Westgarth and Co., Ltd., at West Hartlepool. During the 1914–18 war he held a temporary commission as Engineer Lieutenant on board H.M.S. " Valiant," returning thereafter to the Yorkshire Electric Power Company for a short time before taking up his appointment in 1919 as assistant editor of *The Power User* which later became *Power and Works Engineering*. Shortly after joining the journal he became its editor.

Mr. Arnold was not only gifted with a ready mind and a ready pen, but his genial personality was such that in his forty-two years as editor he made innumerable friends in industry and amongst his colleagues in technical journalism. He will be missed and long remembered by the many who held him in high esteem.

ENGINEERING & MARINE EXHIBITION—No. II

The Engineering, Marine, Welding and Nuclear Energy Exhibition at Olympia, London, will be open daily until Thursday, May 4, and in the pages which follow we continue our descriptions of some of the exhibits to give an impression of the wide range of plant to be seen. Welding and fabrication equipment manufacturers are particularly well represented and many of our notes are concerned with the products of that important branch of industry.



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Sciaky Electric Welding Machines, Ltd.

A special purpose machine of interest shown by Sciaky Electric Welding Machines, Ltd., Slough, Bucks, is designed for use in the mass production of motor-car wheels. In demonstrating this multi-head spot welding machine the maker points out that eight spot welds only are used in the assembly of the wheel rim to the spider and these welds have a shear strength of 21 tons—compared with 14 tons for a wheel assembly riveted in twelve places. The machine is rated at 300kVA and is designed to operate on the maker's three-phase balanced load principle and functions at a power factor in the order of 0·85 per cent. Its output is about 400 wheels an hour and the machine can be adjusted to take wheels of different sizes.

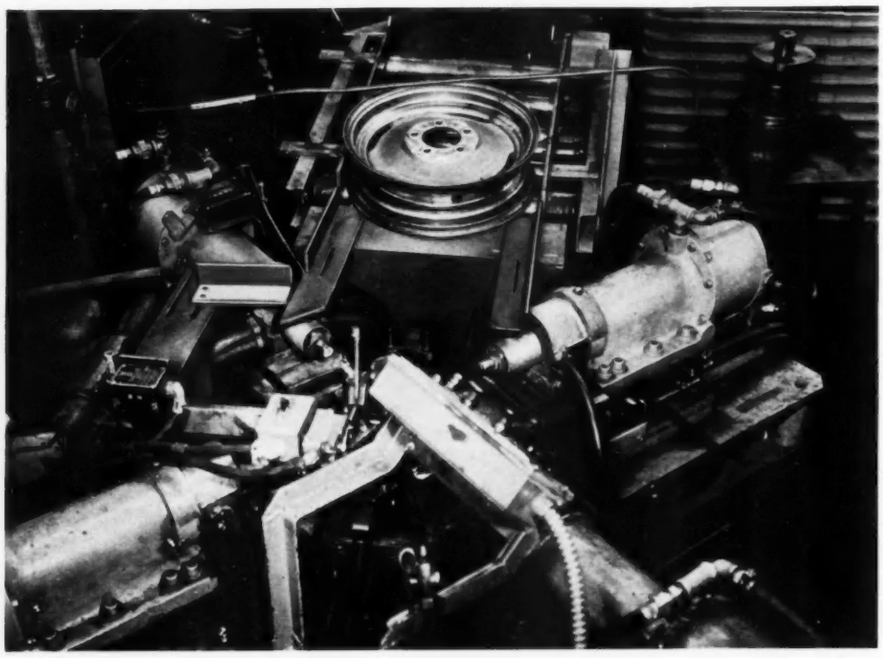


Fig. 38—Automatic special purpose spot welding machine for assembling motor car wheels—Sciaky

In the welder, illustrated in Fig. 38, the wheel assembly is carried on a central indexing head. At the first operative stroke four spots are made and the wheel is subsequently indexed for the further four welds. At the end of the welding cycle the wheel is automatically ejected down a chute. The design is such that the secondary current wave shape of the three-phase welder gives a slow rising build-up of secondary heat, which promotes longer electrode life and ensures correct mating of the piece parts during the forming of the weld nugget. The welds are completed in a multiple pulsing programme to provide steady dissipation of welding heat adjacent to the weld slug, which is usually some $\frac{1}{2}$in in diameter.

Equipment developed from two of these machines now available, will weld 925 wheels per hour, the assembly of the wheel rim and spider and the punching and chamfering of the valve hole being automatically effected in the same set-up.

The firm draws attention to the fact that one of the problems encountered since the introduction of the resistance welding technique is the difficulty in determining with 100 per cent accuracy that the welds are of a desired standard. This is particularly problematic where destruction tests are impossible or extremely costly and, even when applied, cannot absolutely guarantee that the various small factors under the control of operators and setters are strictly adhered to. One such application was recently presented where the projection welding technique was involved on a piece part where the end product was of such a costly nature that the possibility of a weld failure was out of the question.

The Sciaky "P.A.300" machine used in this case is being exhibited. It is of very rigid construction, in order that deflection of the platens under pressure is kept to an absolute minimum. A piston type main pressure cylinder is used in conjunction with low inertia spring loaded tool assemblies, leaving only the small electrode to be accelerated for "follow-up." Furthermore, as described below, it was desirable that a pressure transducer incorporating strain gauges be positioned as near to the weld as possible; this was again made easier by the employment of a piston-type main pressure cylinder.

Maximum flexibility of welding programme was provided by a separate free-standing fully synchronous sequence "Dekatron" control cabinet. The welding current is thus adjustable in time, amplitude and, by means of the slope control, permitted to rise from zero to a preset heat level over an adjustable period of up to ten cycles. Each of the programme periods, i.e. squeeze, slope, weld, hold and off, is fully synchronous and visual indication is provided by the mounting of the "Dekatrons" with the electrodes visible. To obviate the effect of mains voltage fluctuation and changes in secondary impedance due to the possible insertion of jigs into the throat of the machine, a constant current control system automatically detects and compensates for any variation in welding current.

To provide a permanent record of the conditions existing for each weld a special console housing monitoring equipment, including a Kelvin and Hughes recorder, is incorporated in the equipment. The twin-track recorder, in conjunction with the requisite amplifying equipment and strain gauge unit, gives a permanent record of the duration, wave shape and amplitude of welding current, and a waveform showing the characteristics of the pressure application. The initiation of the recording equipment may be either automatic, operating in conjunction with the machine, or under manual control.

A new 50kVA seam/spot welder, based on the firm's "Rapid" machines, is shown connected to the latest "Synchroseam Dekatron" modulating control. Apart from the usual circumferential and longitudinal seam welding, this machine can also be applied to the spot welding of mild steel up to $\frac{3}{16}$in $+\frac{3}{16}$in thickness, and light alloys up to 18 +18 S.W.G.

Lincoln Electric Company, Ltd.

A recent development of the Lincoln Electric Company, Ltd., Welwyn Garden City, Herts, is a CO_2 gas shielded, semi-automatic hand welding set for fine wire welding. Known as the "Sprite" this equipment is designed particularly to meet the requirements of light gauge sheet steel fabricators for a rapid, versatile and easily operated welding unit. The hand welding gun used with the equipment will continuously weld in all positions down to 20 gauge sheet and is stated to produce almost spatter-free welds to Lloyds standard without flux or other weld covering.

The equipment is used with the firm's new constant-voltage motor-generator providing 400A continuously at 40V for 100 per cent cycle duty. A variable stabiliser fitted enables the correct value of inductance to be utilised, thus increasing the welding range. The welding set is illustrated in Fig. 39. It incorporates a steplessly variable wire drive unit; wire reel with an adjustable brake; a spring loaded mechanism which takes up slack wire when the electrode is inched back prior to welding; a remote current control box with a CO_2 gas purge operating button; and a hand welding gun. The variable speed d.c. motor driving the wire feed is supplied with current from the motor generator and is designed to drive

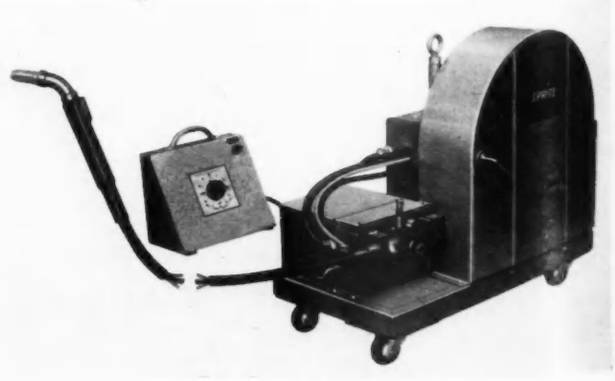


Fig. 39—CO_2 gas shielded arc welding equipment with a separate remote control box and hand welding gun —Lincoln Electric

wires of $^{1}/_{32}$in and $^{1}/_{64}$in diameter at speeds between 130in and 300in a minute.

The welding current range of the equipment is 60A to 200A and the gun used is angled to facilitate manipulation. A single lightweight cable which couples the gun to the wire feed assembly incorporates all the connections—wire, gas and current. Two micro switches fitted to the gun handle control wire feed forward and in reverse. The use of a feed-back switch makes it unnecessary to trim the wire at the completion of each weld and through the forward feed switch the wire can be inched as required before commencing welding.

There can also be seen this company's "Lincoln-Cloos" semi-automatic CO_2 welding equipment which also provides means for spot, plug and tack welding using the same hand gun. This equipment is completely self-contained and occupies less than 6 square feet of floor space. It consists of a hand gun with continuous electrode wire feed and CO_2 gas shielding. The wire is fed to the gun nozzle through a flexible cable by variable-speed drive rolls and the

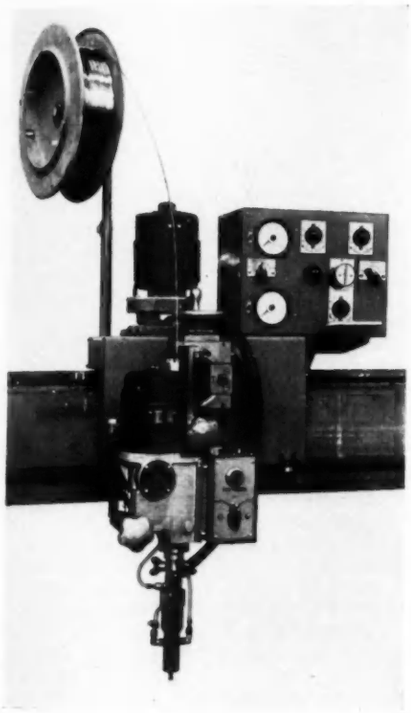


Fig. 40—Automatic CO_2 welding head—Lincoln Electric

control box, drive gear and water cooling system for the nozzle are mounted as a compact mobile unit with provision for the support of two gas cylinders.

A fully automatic CO_2 welding head, Fig. 40, now made is an adaption of the Lincoln submerged arc welding head. It incorporates a high-speed wire feed gearbox and a special CO_2 welding nozzle assembly which is water cooled with a gas shroud and detachable contact tip. The wire feed drive is capable of using the fine wires associated with the CO_2 shielded-arc welding process without a change of gears, and it gives wire feed speeds of 85·3in to 682·6in per minute.

The latest version of the firm's manual equipment is the basic "M.L.2" manual submerged arc welding unit, incorporating a new remote control. This set is designed for use where the application does not permit the siting of the welding generator and the welder unit close to the actual working point. The remote control unit provides full control of the welding currents and voltages and is sufficiently compact to be taken into confined spaces, thus making it unnecessary for the operator to leave his working position to adjust the voltage and current settings on the generator. The equipment can be used both as a manual or as an automatic set to suit individual applications. An "on-off" switch is fitted on the handle of the welding gun for manual operation so that the operator has complete control at the point of welding. For its demonstration at Olympia this new remote control submerged arc unit is powered by a motor generator and mounted on a lightweight column and boom for use in conjunction with a small rotating and tilting work positioner.

Solus-Schall, Ltd.

Non-destructive testing and gauging techniques have been one of the interesting developments of recent years and a number of examples of modern equipments for this purpose are shown by Solus-Schall, Ltd., Honeypot Lane, Stanmore, Middx. In an automatic testing equipment for longitudinal weld testing four miniature 70 deg. angle probes are used in parallel with an ultrasonic flaw detector and flaw alarm device. Water provides a coupling medium and the equipment will detect longitudinal weld defects such as slag, cracks, lack of penetration, lack of side fusion, porosity and also transverse cracks. The equipment is suitable for use with plate thicknesses between 5mm and 15mm. This system can be adapted for use on spirally welded seams, including reverse spiral welds which arise when two sections of strip are joined together.

A gauge designed for the rapid checking of metal or paint coating thickness of ferrous materials has a hand probe which is moved over the coating and an alarm is sounded when the coating falls below a predetermined standard. The gauge is transistorised and operates from a self-contained battery with a life of from four to six months. It can be carried in an overall pocket and its portability permits rapid checks to be made in precarious and normally inaccessible places. The probe face has built-in ball bearings which enable it to slide easily and smoothly over sprayed surfaces and prevent wear.

A magnetic thickness gauge which measures the thickness of steel tubes or steel plates can be operated from a battery or the power mains. It consists of a control unit and a magnetising probe. The probe is held to the tube or plate to be tested and, when the magnetising push button is depressed, steel thickness is shown on a meter. The control unit provides two meter ranges to measure up to 8mm steel thickness. An instrument known as the "Conductitest" has been developed as a versatile and easily operated inspection device for the non-ferrous industry. By measuring the electrical conductivity of non-magnetic metals this instrument also gauges porosity, hardness and other characteristics. It can be used for detection of impurities in metal, sampling of melts, identification and sorting, locating surface cracks, measuring coating thickness, and testing tensile strength of aluminium.

This firm's "Junior" mobile magnetic crack detector is designed to detect surface and submerged cracks in ferro-magnetic materials by means of magnetic particles. The specimen to be tested is magnetised by a current flowing round or through it, whereby a magnetic field is set up at right angles to the direction of the current. A magnetic flux in the specimen will stray into space at a defect. After the specimen has been magnetised it is sprayed with coloured magnetic powder or a coloured magnetic ink, the particles of which will be drawn by the stray magnetic field thus revealing the defect producing it. The detector is of medium output and can supply 2000A a.c. or 2000A halfwave d.c.

Murex Welding Processes, Ltd.

Some of the many applications of the "Muramatic" automatic welding head and a selection of the new and improved manual arc welding electrodes are to be seen on the stand of Murex Welding Processes, Ltd., Waltham Cross, Herts. The "Muramatic" head is intended for use with either the submerged-arc or open-arc process using either a.c. or d.c. supply, and with welding currents of up to 1200A. The head can be mounted in many different ways and it can be used in the form of a single or double-headed deckwelder or mounted on booms, columns, mobile platforms, &c. A range of ancillary equipment, available from the maker enables complete installations to be built to suit production requirements. In Fig. 41, there can be seen a typical single-

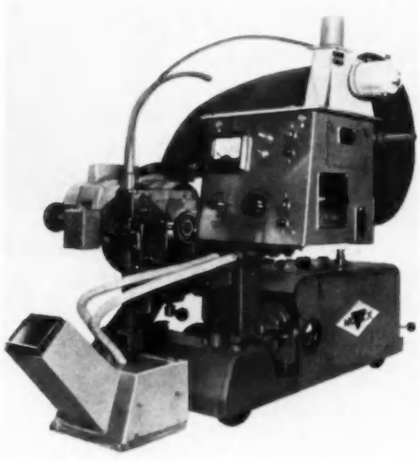


Fig. 41—Single head deck welding machine—Murex

head deckwelder mounted on a carriage having a speed range of 8in to 40in per minute. The equipment is steerable and the power drive to the wheels can be disengaged by means of a clutch, whilst the use of centre-grooved wheels facilitates track mounting when required.

An automatic fillet welding equipment for making two horizontal-vertical fillet welds simultaneously on the opposite sides of a stiffener consists of two "Muramatic" welding heads mounted on a self-propelled carriage. It is suitable for use with the submerged arc or the open arc processes using a continuous coated electrode. Either a.c. or d.c. at any value from 300A to 1200A can be used by each head and the equipment is supplied with all necessary controls for electrical and mechanical adjustments, including the accurate alignment of the welding arcs by guide wheels.

Power packs to operate with the "Muramatic" equipment, which are available in two different capacities of 750A and 1200A maximum, are of transformer, motor-generator, rectifier or transformer/rectifier type. These packs have motorised remote control enabling the current to be steplessly adjusted from the welding head either before or during welding. All of the firm's rotary welding equipments incorporate the "Dynex" or type "3000" welding generators which give a stepless current adjustment over the complete power range.

Baker Perkins, Ltd.

A selection of the welding manipulative equipment made by the Yates plant division of Baker Perkins, Ltd., Peterborough, includes the twin-pillar revolving welding column with a retractable and elevating boom which is shown in Fig. 42. The twin-pillar column of this machine is mounted through a thrust slewing rim on a revolving platform on a travelling carriage. It can be swung by hand through 360 deg. and locked in any required position. The retractable boom passes through a cross head carried on rollers in machined guides in the twin pillars and through this cross head the boom has a vertical travel of 10ft 6in. A geared motor mounted at the top of the pillars is used for elevating the boom assembly, the drive being taken through a slipping safety coupling and reduction gearing. The supporting chains used for boom movements are connected to counterbalance weights within the column. The boom passes through the cross head and, by power, can be extended and retracted at stepless speeds ranging from 6in to 72in per minute when welding. With a maximum movement of 12ft the boom gives a full welding reach of 17ft from the centre line of the column.

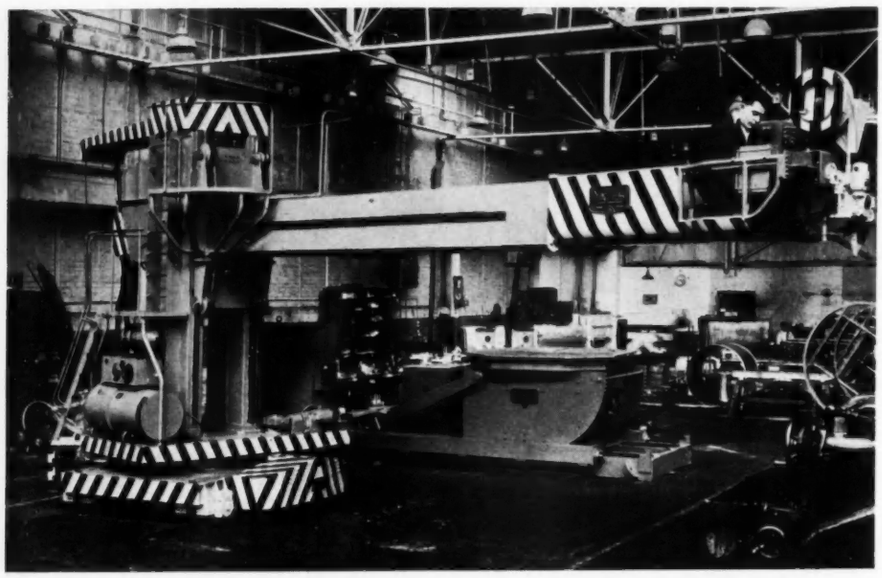


Fig. 42—Universal column with retractable boom for use with welding heads—Baker Perkins

One of the company's 10-ton capacity self-aligning travelling rotator sets, shown in Fig. 43, is designed to accommodate vessels from 2ft to 12ft diameter about a common centre line. Each of the two units forming the set is of heavy welded steel design complete with an integral bogie frame. Each unit is independent of the other and the power unit can be traversed on 4ft 8½in gauge shop rails in both directions at infinitely variable welding speeds. A four wheel drive, together with double flange wheels on one side and plain wheels on the other side ensures smooth movements without any tendency for nosing on the track. The traversing motors drive through two worm reduction gearboxes, the final one incorporating a releasable slipping clutch which can be disengaged to allow the unit to freewheel.

A Ward-Leonard drive gives stepless welding speeds of 4in to 40in per minute for both rotational and traversing movements, a change-over switch being used to select the required movement. A control box mounted on the power unit frame is fitted with a visual welding speed indicator, calibrated in inches per minute welding speeds, speed control, start/stop buttons, reversing switch and pilot light. This control box can be detached and positioned on a welding boom or any other convenient location if necessary.

A 100-ton heavy-duty rotator set with one power and one idler unit is designed to take vessels from 3ft to 20ft diameter. In these equipments a d.c. geared motor mounted in each power carriage drives through a non-releasable overload slipping clutch to a pinion which meshes with an internal gear ring housed in the rotator roll. Each rotator roll has an iron supporting centre wheel located between two rubber tyred wheels of slightly larger diameter which impart the driving torque to the vessel. These heavy duty rotator sets can be fitted with self-propelled carriages which open or close under their own power to suit the various diameter vessels.

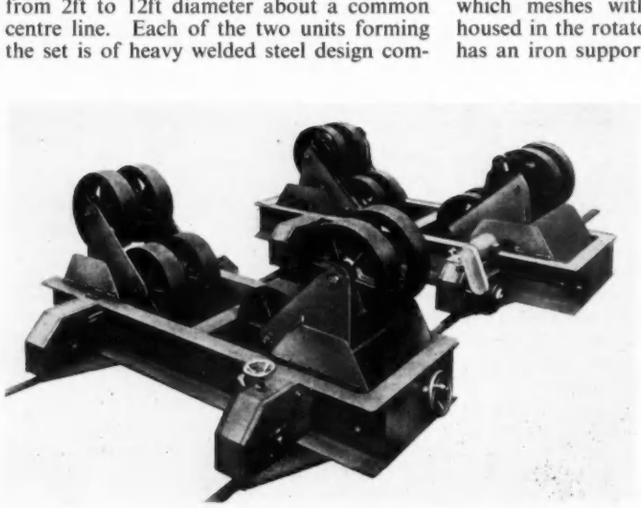


Fig. 43—Self-aligning travelling rotator set for cylinders from 2ft to 12ft diameter—Baker Perkins

A rocking manipulator shown by this firm has a capacity of 5 tons rated at 1ft 6in centre of gravity from the table face when at 90 deg. at 1ft. eccentricity. Its design is such that the 5ft 6in square table can be tilted to a maximum angle of 90 deg. by rocking the side plates on the heavy fabricated base and all the weight of the work-piece acts directly down on to the base without imposing undue stress on the tilting mechanism. The lifting arms are actuated by a trolley arrangement which is operated by a lead screw. A three-dimensional floating nut fitted in the trolley is non-binding for all angles of tilt and a safety coupling incorporated slips and audible warning is given if the table is fouled against an obstruction or is excessively overloaded. The drive to the lead screws is by an a.c. motor fitted with a magnetic brake and limit switches ensure that over-run does not occur. Barrel-shaped teeth on the curved side plates mesh in holes drilled in the machine base to prevent any tendency for skidding.

Rockweld, Ltd.

The "Comet" equipment for CO_2 semi-automatic welding with a flux-cored wire has been modified considerably in a new model shown by Rockweld, Ltd., Commerce Way, Croydon, Surrey. This machine can be used with any conventional power source—preferably with an open-circuit voltage of 70V. The flexible wire feed tube used by the operator is 15ft long, and additions to the machine to enable fully-automatic welding are shown for the first time on two self-propelled carriage models. The first of these machines comprises a carriage with a pillar-mounted adjustable arm on the extremity of which a wire nozzle is fed from a relatively short length of feed tube. This arrangement permits the nozzle to be pointed at suitable angles for a wide variety of joints. Provision is made for manipulation of angle and lateral displacement of the nozzle while welding is in progress, thus taking full advantage of the visible arc.

The second machine, known as "Duomatic," is specifically designed for the attachment of stiffeners in ship fabrication. With the control provided intermittent welding may be used, thus avoiding buckling due to weld contraction, and simultaneous fillet welding on each side of the stiffener may be continuous or intermittent as required.

A new machine for vertical welding of plates from ½in upwards is known as the "Vertomat." It utilises two water-cooled shoes boxing the weld metal between the plates being welded and a CO_2 shrouded arc; no slag is used in this process. High welding speeds are obtained in a single pass—up to approximately four times faster than that of manual vertical welding. The equipment comprises vertical rails on which is mounted a welding head carriage which incorporates the control for vertical movement, wire feed and oscillating mechanism—the latter being necessary for welding plate thicknesses of 1¼in and above. Pressure switches and relays ensure that welding is stopped in the event of failure of CO_2 gas to the weld or water coolant to the shoes. Control of the wire speed vertical traverse, welding current and voltage and positioning of the weld nozzle are all adjustable by the operator during welding.

English Electric Company, Ltd.

The arc welding equipment and accessories being shown by the welding division of the English Electric Company, Ltd., English Electric House, Strand, London, W.C.2, includes the "LWAD" range of welding equipment, which gives either an a.c. or d.c. output at the turn of a switch and can be used both for metal arc welding and as a power source for inert gas welding processes. These sets are particularly suitable for use in areas where trained maintenance engineers are not readily available. They have a static power source, containing no moving parts, and hence needing little maintenance.

Being oil cooled, the sets are suitable for use in all climates and their silicon diode rectifiers are also oil cooled to prevent damage by over-heating. It is stated that these equipments will operate successfully at temperatures up to 190 deg. Cent.

The three sets included in this range are designed for a maximum continuous hand welding current of 250A, 350A and 624A, a.c., or 200A, 280A and 520A, d.c. respectively, in thirty-six steps, their continuous ratings being 12·6, 18 and 30·6kVA. In these machines, one of which can be seen in Fig. 44, a steel tank mounted on three

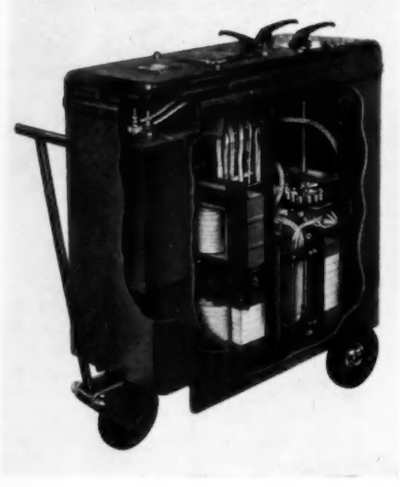


Fig. 44—a.c./d.c. welding equipment—English Electric

wheels contains the transformer, current regulator, a bank of silicon diode rectifiers, smoothing choke and control switches, all completely immersed in oil. A dry compartment is provided at the drawbar end for the fitting of a power-factor correction capacitor if required.

For use where demand does not justify the installation of a multi-operator plant the firm has introduced five sizes of "LWC" sets covering welding currents from 30A to 630A. One of the sets in the range contains two current regulators and can provide two welders with 315A each, or when occasional heavy current welding is required, the outputs can be paralleled to provide 630A for one welder. Like the "LWAD" range the power source is static and the equipment is oil cooled. Power factor correction capacitors can be fitted.

A new meter has been introduced for a.c. welding production, research and development purposes. It measures the electrical conditions in a welding arc and can be applied in costing, calculating efficiency, developing electrodes and improving production techniques, e.g. in determining the ideal cooling rate for various metals.

The instrument consists of a watthour meter, ammeter, voltmeter and protective relay housed in a compact case suitable for switchboard or wall mounting.

Gas Council

Research teams in the Gas industry have played a large part in bringing automatic control to industrial appliances and some recent equipment of interest is being shown on the stand of the Gas Council. From a control panel on the front of the stand, visitors are able to light up a forge furnace or start an air heater developed for use in industrial ovens. Also connected to this centre panel is a packaged conversion burner for process air heaters and other industrial uses. This burner set was developed by the North-Western Gas Board's industrial gas development centre and is said to be the first British-made gas unit ready "packaged"—complete with fan, automatic ignition and all control equipment. Another development is a brass billet heating furnace which was designed by the South-Western Gas Board and is exhibited to show the vast improvements in operation and efficiency over much existing equipment in use in the brass stamping industry. A prototype of a flash melting machine shows how the particular qualities of gas have enabled the development of a new process to melt non-ferrous metals more rapidly and economically than by existing methods.

The air heater is one of a range of complete recirculation direct fired heaters and fans which are intended for application to ovens or other process air heating applications in order to obtain high circulating volumes and low temperature differentials. The high rate of recirculation and accurate control of air flow obtainable ensures the minimum consumption of gas coupled with a rapid rate of heating from cold and rapid recovery of temperature following loading. The recirculation return duct connection and the outlet from the fan can be arranged so that the heater can be mounted on the top or at the side of the oven. Control equipment is supplied as standard and the only work on site is connecting to electrical mains, gas supply, thermostat and ducting. The sheet steel casing is lined internally with asbestos composition or similar insulating board and encloses an alloy heat-resisting steel combustion chamber cooled by the recirculating air. The recirculation air and products of combustion mix together and are drawn into the recirculating fan. A slot burner fires into the diverging combustion chamber and accurate control of combustion air is obtained by adjustment of a sliding damper plate, which after initial setting is locked in position. The normal maximum temperature for the air leaving the heater is 600 deg. Fah., but higher temperatures can be obtained with little modification.

The automatic brass billet heating furnace to be seen in Fig. 45 handles billets three inches long and up to two inches in diameter. An automatic feeder is fitted and the billets are carried down a vertical furnace which occupies a space of up to three feet square. The furnace can be set to automatically discharge billets at a predetermined rate or singly by the operator pushing a button.

The North-Eastern Gas Board began work early last year on the development and design of a furnace for the rapid melting of non-ferrous metals. Following a series of development projects the design of flash melting furnace on show was evolved. This furnace has a melting capacity of approximately 100 lb per charge and incorporates load recuperation in addition to combustion air pre-heating. In the general sequence of operation the load is placed in the recuperation section and the entire 100 lb charge may consist of pre-alloyed billets, scrap, &c. Normally, the charge would remain in this section for a period of eight to ten minutes, while the previous 100 lb. charge was being melted in the melting section. The furnace exhibited is capable of 100 lb melts in about eight minutes and has an hourly capacity of from 5 to 5½ cwts.

On production trials, the equipment is stated to have proved very successful in operation from at least three aspects : it gave much improved quality of metal cast as

Fig. 45—Brass billet heating furnace—Gas Council

compared with crucible furnace techniques ; there was a marked reduction in metal loss during the process ; and the fuel consumption per lb. of metal was very much reduced as compared with conventional methods. The furnace gives a continual discharge of molten metal into a holding section or pot which is maintained at a temperature suitable for casting by a small auxiliary burner. The arrangement and disposition of the burners used for firing this furnace are such that any type of atmosphere required adjacent to the metal being heated can readily be achieved and these conditions can, if necessary, be varied in accordance with the types of material being melted. During the time the initial charge is in the load recuperation section, it is generally raised to a dull red heat prior to its insertion in the melting section. Under normal conditions the combustion air is pre-heated to something in excess of 300 deg. Cent.

A Peddinghams automatic gear hardening machine on the Gas Council stand demonstrates the important advance made in the design of flame hardening plant, in the spin hardening method. Machines of this design are made in a number of sizes for the treatment of components ranging from small pinions up to gears of 5ft diameter and having teeth of over 10in in width. As the complete cycle of operations is pre-set on the machines consistent and accurate results are ensured. All machines are equipped for automatic temperature control.

Associated Electrical Industries, Ltd.

Most of the welding equipment displayed upon the stand of Associated Electrical Industries, Ltd., Trafford Park, Manchester, is shown in operation and one such demonstration of submerged arc welding shows how various items of equipment can be assembled into special purpose machines. An example of submerged arc equipment, illustrated in Fig. 46, is that at the works of George Clarke (Sunderland), Ltd. This

Fig. 46—Automatic submerged arc welding equipment in use—A.E.I.

automatic welding equipment using a bare electrode and granular flux is designed to give rapid deposition of weld metal to comply with high radiographic inspection standards. The use of electronic control ensures a reliable arc and instantaneous initiation of the arc to avoid imperfections at the beginning of a weld. The equipment can be adapted to operate an a.c. or d.c. and can be converted for open-arc welding using a flux coated electrode.

This firm's new "Paradyne" portable d.c. single operater welding set is designed to give smooth control from 30A to 400A. It consists of a motor-generator set with control gear, selector switches, and motor starter. The d.c. generator has a drooping characteristic to reduce power loss during welding. Another portable equipment demonstrated is the single operator "Thermac" a.c. arc welding machine, which is suitable for 400V, 420V, or 440V supply and gives 250A or 350A maximum continuous hand welding current.

A heavy-duty general purpose projection welding machine on the stand has a thermal rating of 150kVA at 50 per cent duty cycle and its typical welding capacity is six projections in 0·080in mild steel sheet.

Many of the products of the turbine-generator division of Associated Electrical Industries, Ltd., are too large to exhibit at Olympia and use is made of special photographs to illustrate heavy plant. Two large coloured cut-away drawings show examples of heavy steam turbines and generators—one a hydrogen- and water-cooled generator and the other a steam turbine for nuclear power plant application. The generator is a 200MW machine, one of two being built for the C.E.G.B. power station at Willington, and similar to two for the Hazelwood Power Station of the State Electricity Commission, Victoria, Australia. It is hydrogen-cooled with vertical coolers in separate end compartments, and the stator incorporates the system of direct water cooling that was pioneered by A.E.I. and first used in 1956 in a prototype machine at Bold "A" Power Station.

The steam turbine is one of four 3000 r.p.m. 83MW, mixed-pressure machines installed at Berkeley Nuclear Power Station. A feature of these turbines is that they are designed to run on large quantities of steam at relatively low pressure and temperature conditions, and this calls for a large exhaust area, which is achieved by a multi-exhaust system. The high-pressure steam enters the turbine at 310 lb per square inch and 604 deg. Fah., after expansion through six turbine stages it is mixed with low-pressure steam at 64 lb per square inch and 596 deg. Fah.

The principal industrial gas turbine exhibit will be a model of the Gach Saran Power Station, recently built by A.E.I. for the Iranian Oil Exploration and Producing Company. The station houses three L51C gas turbines, each driving a 5·5MW salient-pole generator. The turbines supply power for the operation of two distant oil producing units, a water pumping station and an adjacent housing estate. The station is completely self-contained and is not connected with any outside source of power. Provision has been made for the installation of three more generating units since it is expected that the oilfield will develop and the demand for electricity will increase.

A large display panel shows, in diagrammatic form, plant for the shipbuilding industry, including geared main propulsion machinery, engine-room auxiliary equipment, closed feed-water systems, cables, switchgear, radar equipment, electronic equipment, lighting and lighting fittings. A 700kW back-pressure marine auxiliary turbine-generator also shown has been designed to operate at steam conditions of 550 lb per square inch gauge and 890 deg. Fah. and to exhaust at 31 lb per square inch gauge into a low-pressure steam power system. The turbine has a two-row velocity-compounded stage followed by six single-row impulse-reaction stages and will run at 8000 r.p.m. It drives a 440V, 60 c/s, salient-pole generator at 1800 r.p.m. through a double-helical single-reduction gearbox.

The gas turbines, forming part of the combined steam-turbine/gas-turbine geared main propulsion machinery developed for use in the Royal Navy's general-purpose frigates and guided-missile destroyers, are also represented by a number of exhibits. The combined machinery enables the ship to operate economically while cruising on the steam turbines, the gas turbines being used to provide additional boost power when the highest speeds are required.

Exhibits illustrating the condensers and heat exchangers for use in the electricity supply, petroleum, chemical and other industries includes a demonstration of methods of tube to tube-plate fixing used in the A.E.I. heat exchanger works. Both automatic torque control tube-expanding and automatic tube-end welding are demonstrated. The latter is carried out by means of a welding gun capable of welding tubes of from ½in to 1½in in diameter. The heat exchangers exhibited include an extended-surface hydrogen cooler, and typical shell and tube units.

A model of a glass-fibre condenser waterbox shown has been used as part of the development of waterboxes manufactured from synthetic resins for service in areas where cooling water would cause graphitic corrosion of cast iron.

The Motor and Control Gear Division is showing a new direct-on-line 5 h.p. contactor starter (DOC80) for both single-phase and three-phase motors. It is equipped to give protection against single-phasing on three-phase supplies and incorporates an ambient temperature compensator to allow for differences in the local temperature at the starter and the motor. A range of interchangeable component assemblies simplifies stockholding. The starter is normally supplied with one of five operating coils and there is a choice of fifteen thermal overload heaters to give accurate protection to the motor.

On the same stand there is a totally-enclosed, water-cooled, high-frequency motor-alternator set rated at either 300kW at 1 to 3 kc/s or 150kW at 8 to 10 kc/s; its design is based on the 70kW at 8·7 kc/s set introduced two years ago. It consists of a heteropolar inductor and a squirrel-cage induction motor mounted vertically on a common shaft and in a common frame. The motor is carried by a thrust-and-guide roller bearing at the bottom of the shaft with visual indication of the lubricating oil level. The top bearing is a grease-lubricated guide roller bearing. The motor is air cooled, the heat being removed by an air/water cooler fitted around the motor frame. In the alternator cooling is partly by an air circuit similar to that of the motor and partly by a water-cooled circuit built into the stator core. The cooler pipes are brought out to a terminal box on the machine. Bearing oil temperatures are measured by vapour pressure thermometers fitted with double alarm contacts, and thermocouples are installed to measure the circulating air temperatures.

A range of magnetic crack detectors for locating flaws in ferrous materials is being

shown by the company's Instrumentation Division. The range includes the PM equipment—a small portable detector (Fig. 47 which has a permanent magnet of high

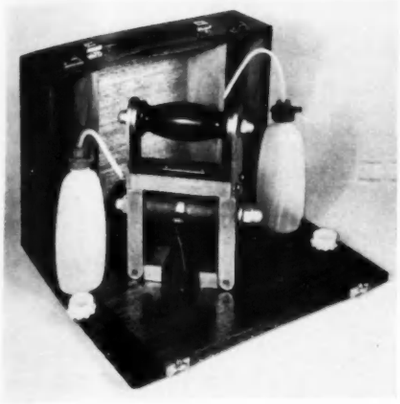


Fig. 47—"PM" Magnetic crack detector—A.E.I.

coercivity as a source of flux, and is specially suitable for the testing of large parts such as pressure vessels and alternator stator frames.

The material of the permanent magnet is "Alcomax III," 3½in long, clamped between two mild steel pole limbs of 1·75in by 0·75in cross section and 5·25in in length; the ends of the limbs remote from the magnet terminate in hinged tips, enabling good magnetic contact to be made on curved surfaces. Provision is also made for angular displacement of one of the pole limbs about the magnet axis, which enables more complex shapes to be tested.

An important characteristic of this crack detector is the provision of shunt control. The magnetic shunt consists of a mild steel bar, fitted with a handle, which bridges the ends of the pole limbs adjacent to the magnet. With the shunt in position, the magnetic flux is effectively "short-circuited" by it, and the crack detector can be positioned on and removed from the surface under examination with great ease. When the crack detector has been positioned as required for carrying-out a test, the shunt is removed with a twisting or sliding motion, breaking the magnetic circuit first at one limb and then the other, thus re-routing the magnetic flux through the material under test. When the shunt is in position, the magnetic pull is strong enough to allow the complete magnetiser to be carried by the shunt handle.

The type PM crack detector is supplied with a wooden carrying case, which also accommodates two polythene spray bottles for magnetic fluid. The weight of the magnet is about 5 lb, and it produces a field strength of about 700 lines per square centimetre in a 1·75in air gap.

British Federal Welder and Machine Company, Ltd.

The exhibits of British Federal Welder and Machine Company, Ltd., Dudley, Worcs., show a part of the company's range of standard resistance welding equipments together with working models and photographs of special purpose equipments. The exhibits include the latest design of the company's automatic high-speed drum forming and welding equipment, for the production of 45-gallon drums. This machine is fed with pre-cut blanks and its cycle includes means of automatic roll forming to the required drum diameter after which the formed components are carried through a conveyor section into the sizing and welding head in which the drum bodies are mesh-seam welded. The output of the 250kVA capacity machine exhibited is in the order of 400 drum bodies per hour and the machine can be provided with a crushing roll unit on the exit side to form a completely flush internal joint suitable for subsequent lacquering. The machine has an automatic cross index movement on the upper and lower welding wheels to provide uniform wear and prevent the formation of grooves in the wheel track, thus ensuring that the quality of the mesh-welded joint remains consistent. It is designed to accommodate a range of drum diameters and the sizing roll head is rapidly replaced to accommodate such changeovers. Drum bodies up to approximately 42in long and varying from 26 to 16 gauge are handled by the machine. A typical equipment illustrated in Fig. 48 is of the light-duty design employing a single drive to the lower welding roll—heavy-duty machines being provided with a double drive.

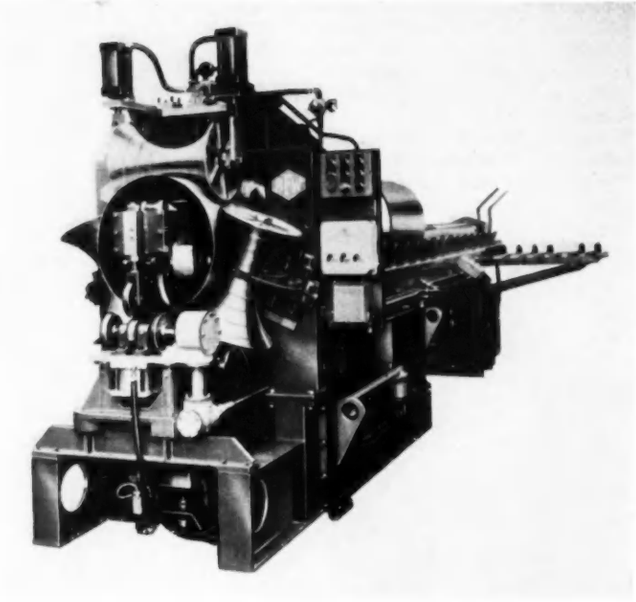


Fig. 48—Automatic drum forming and welding machine with an output of 450 45-gallon drums an hour—British Federal

Special purpose installations shown in the form of working models illustrate a completely automatic "conveyorised" high-speed production line for manufacture of a British automobile underbody. The line which is capable of producing complete underbody assemblies at the rate of 120 per hour, employs an automatic shuttle feed and sub-assembled sections are automatically fed on to the main line from preassembly stages. A similar line which is completely automatic is illustrated in relation to the British Federal automatic automobile door clinching and welding equipment. This shuttle fed line incorporates pre-clinch multi-welding stations, automatic clinching stations and after-clinch weld stations and the line illustrated is used for outputs of up to 120 doors per hour, although higher outputs can be obtained when required.

A number of electronic controls including a fully transistorised timer unit incorporating printed circuitry are exhibited. A sensitive overload protection relay unit shown is applicable to any motor-driven machine tool. It measures the true load condition of the motor current and is capable of instantly operating a signal, or trip, in the event of overload occurring due to faulty tooling or any other variable. Illustrated in Fig. 49 is one of the firm's range of unitised D.P.I timer units which are designed to provide multiple controls for multi-welders or any multiple stage sequence.

The standard equipments include a number of light duty standard machines covering diverse applications and ranging from pedal operated spot welding machines and pedestal butt welders to medium duty seam and spot welders.

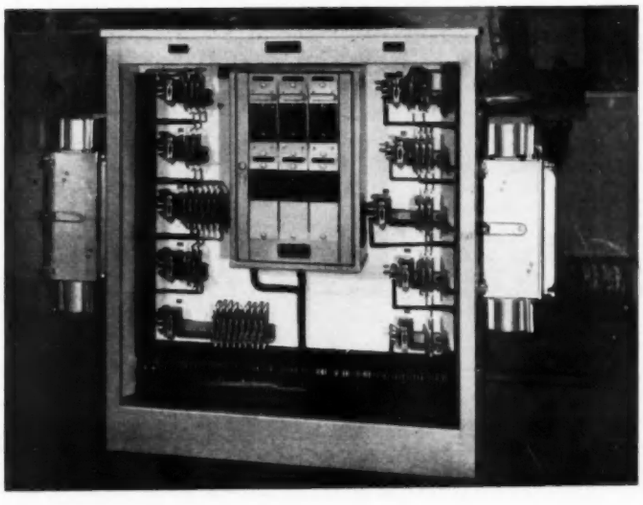


Fig. 49—Typical control cubicle incorporating multi-stage plug-in D.P.I. timer units with independent heat control—British Federal

Arc Manufacturing Company, Ltd.

The semi-automatic carbon dioxide welding equipment demonstrated by the Arc Manufacturing Company, Ltd., Nitshill, Glasgow, S.W.3, uses a light hand gun, an integrated wire drive, a control unit and a 600A constant power source. The wire drive unit, which can be mounted in any convenient position, incorporates a governed feed motor, dual-drive feed rolls ; post-purge gas and water timer and solenoids ; safety water pressure switch and control relays, all built into a sheet metal cabinet. The 600A constant potential silicon rectifier with a range of 0 to 45·4V at rated load is rated for an 100 per cent automatic duty cycle. A slope control provided gives five position adjustments of output characteristic from flat (0·60V per 100A droop) to drooping (8V per 100A).

A new three-phase rectifier has been introduced by the firm with a view to providing the welding characteristics connected with d.c. current and the economies of a.c. equipment. This rectifier (Fig. 50) has a

Fig. 50—Three-phase rectifier with a smoothly variable output between 45A and 450A—Arc

smoothly variable current range of 50A to 450A and is rated to B.S.S. of 400A at 35V ; the secondary voltage being 70V.

The recently redesigned " Actarc Polytrode " has a spark gap ioniser which facilitates arc welding by superimposing a high-frequency current on the normal low voltage welding current. It can be used with standard a.c. or d.c. machines and adapts a normal welding transformer with a minimum open-circuit voltage of 90V for the welding of non-ferrous metals with coated electrodes. It facilitates the striking of the arc, which is initiated as the electrode approaches the work, and the control of arc length. The supply voltage is 230V a.c., 50 cycles ; the input being about 150W, and the permissible welding current 300A at 60 per cent duty cycle.

Hancock and Co. (Engineers), Ltd.

A lightweight flame planer and a tube profiling machine are two new products of Hancock and Co. (Engineers), Ltd., Progress Way, Croydon, Surrey. The flame planer (Fig. 51) is designed to cut on all four sides of a 12ft wide, 30ft long plate simultaneously and give the usual edge preparation for welding. The machine can also be adapted for contour cutting plates.

The cutting heads are carried on three gantries which run on precision ground rails and the main gantry, which carries heads for making the longitudinal cuts simultaneously, is propelled by a variable speed motor. The two gantries for making the end-cuts carry variable speed motorised tractor units, each of which is fitted with a compound burner-head for making transverse cuts. Controls for the machine are centralised at a position convenient for the operator, and the burners are controlled by switches operating solenoid valves.

The new tube profiling machine is capable of producing its own templates from a drawing, and is designed for the weld preparation of pipes from 3in to 12in in diameter. The standard machine deals with the preparation of branches, and an optional attachment is available for cutting the corresponding holes in the main pipe. These cuts can be made for pipes to be set either at right-angles to each other or at any desired angle of off-take. The templates are made direct from drawings by means of a special attachment on the machine. The templates may be made from stock pipe, and drawings are available to cover a complete range of standard pipe sizes and angles—a " library " of standard template drawings being supplied with the machine.

By a multiplying device provided with the machine templates can cover a range of pipe sizes, for instance the template for cutting a 3in pipe at 45 deg. to weld into a 6in pipe may also be used for a 6in pipe to be welded into a 12in pipe at the same angle. The machine is driven by fractional horsepower motor with steplessly variable speeds and the whole equipment is a self-contained unit which may be easily transported.

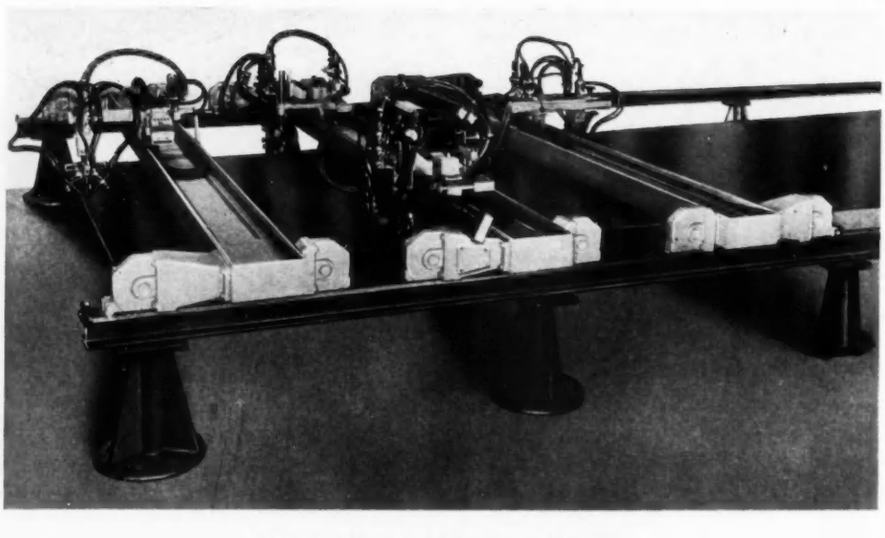


Fig. 51—Lightweight flame planer—Hancock

Kerry's (Ultrasonic), Ltd.

Under an agreement with Omark Industries Inc., of the United States, a branch of Kerry's (Ultrasonics), Ltd., Warton Road, London, E.15, is now marketing that firm's percussive, high capacitance, stud welding equipment in this country. With this equipment studs up to ¼in diameter can be welded to sheet metal down to 0·020in thick without distortion or weld burn.

In this process welding is effected by the discharge of a low d.c. voltage, high current through a special tip on the stud and this tip initiates an arc on contact with the workpiece. A current flow causing ionisation melts the face of the stud and a similar area of the work. This current flow is about 300,000A per square inch with a voltage potential of under 150V, and the duration of the arc is nominally one millisecond. Arc intensity for welding metals of different conductivity and thickness and according to the diameter of the stud is

Fig. 52—Portable stud welding machine—Kerry's

provided for by selection of stud tip length, diameter and shape ; and by the adjustment of weld current available at the tip by control of the speed at which the stud is brought into contact with the work.

The system is stated to produce little penetration of arc into the base material—only between 0·005in and 0·010in—and beyond this point there is no structural change in the metal. With it any low carbon ferrous or non-ferrous metals may be welded, including steel to steel ; steel to lead-free brass ; steel to stainless or plated steel ; or aluminium to aluminium, zinc base materials, copper titanium, &c. The studs supplied in various metals and sizes can be threaded or plain and nails or pointed studs are also available.

Stationary, portable or bench mounting welding machines are available and with these machines the " energy " discharge is controlled from either foot or hand-operated valves, and by setting the variable weld gun and control pressure precise welding conditions are obtained. In the machine (Fig. 52) a motor generator supplies the potential to weld storage capacitators.

Ultrasonoscope Company (London), Ltd.

The non-destructive testing equipment made by Ultrasonoscope Company (London), Ltd., Sudbourne Road, London, S.W.2, includes the new portable ultrasonic flaw detector shown in use in Fig. 53. This equipment has a fast time-base speed and high trace brightness combined with a rectified or un-rectified trace display which enables a comprehensive study of the flaw

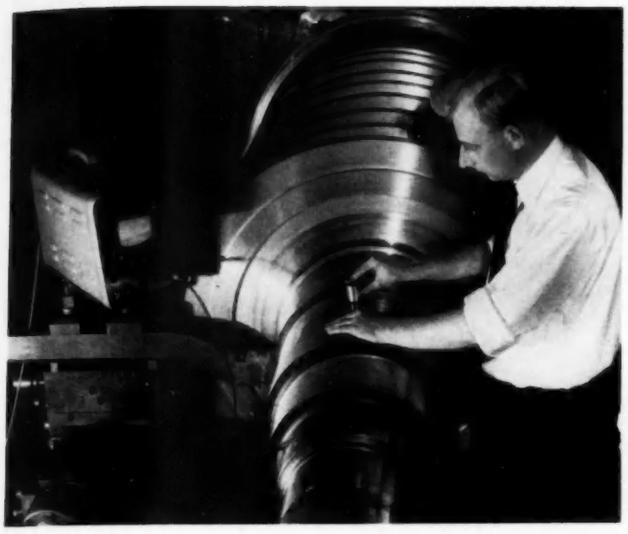


Fig. 53 — Non-destructive testing of a high-pressure rotor shaft—Ultrasonoscope

echo shape. It has an operational frequency range of ½ to 10 Mc/s and a time-base range in steel from 1in to 20ft. The 5in diameter high-definition cathode-ray tube is designed to reduce operator-fatigue when viewing.

A research immersion tank equipment and probe manipulator recently introduced gives inspection probes a 10in vertical adjustment with a rotational adjustment of 360 deg. about the vertical axis. The probes can also be tilted about the horizontal axis from −10 deg. and to the vertical through 200 deg. The design incorporates provision for the crystal face of the inspection probe in accordance with the tilt after it has been inserted in the manipulator. An adjustment, independent of the scaled manipulator controls, enables the probe to be aligned with respect to the specimen.

Perkins Gas Turbines, Ltd.

Two new gas turbine generating sets and a gas turbine instruction set are shown by Perkins Gas Turbines, Ltd. at Olympia.

The " Perkins Mars " gas turbine driven d.c. generator equipment shown in Fig. 54 comprises a gas turbine coupled to a d.c. generator by a " Twiflex " clutch coupling and, excluding fuel tanks, the overall weight is approximately 875 lbs. The turbine, supported in its own frame, is started by means of a single hand crank and its acceleration is automatic after cranking to an output speed of approximately 1000 r.p.m., the fuel valve having been turned on at a speed of 500 r.p.m. With the clutch used the inertia of the generator is relieved during the hand cranking and during subsequent acceleration up to an output speed of about 2700 r.p.m. At this speed the clutch engages and the engine and generator further accelerate automatically to the rated speed of 4400 r.p.m. The d.c. generator supplied by Lancashire Dynamo and Crypto, Ltd., for this set is continuously rated to give an output of 30kW at 220V. The machine is of standard screen-protected drip-proof construction and apart from being provided with a high-speed commutator and special armature banding, it is of normal construction, built to the requirements of B.S. 2613/1957. As an alternative to the standard industrial machine there can be provided a marine type generator built to the requirements of Lloyds Register of Shipping.

A " Jupiter " gas turbine coupled up to a 330kW Smit-Slikkerveer d.c. generator to be exhibited is rated at 525 b.h.p. and is fitted with a combustion air starter capable of starting the engine in ten seconds. The set weighs approximately 4½ tons with base plate and its relatively small size makes it suitable for the supply of shipboard auxiliary or emergency power. The 220V, 1500A generator is flexibly coupled to the turbine output shaft, and runs at 1800 r.p.m. It is a horizontal, drip-proof ventilated machine with bearings force-fed by built-in oil pumps. The control gear is contained in an integral housing, the whole machine being finished to tropical standards and Class-B insulation

The set is fitted with a completely automatic starting system and emergency shutdown devices and can be started by remote control. The starting circuit can also be energised by an undervoltage relay to bring the set into operation in the case of power supply failure. If required an electric starting equipment can be supplied in place of the combustion air starter. Once the engine is on load, control is by a governor which maintains the engine speed to very close limits and large load changes can be accepted by the engine with only small variations in speed.

The " Perkins Mars " gas turbine instruction set consists of a 50 h.p. turbine fitted with a dynamometer and other special equipment to measure every aspect of its performance. A separate instrument console houses manometers, a multi-point pyrometer, fuel flow measuring device, and other equipment required for performance calibration. The unit is started by a hand crank on the engine. The turbine is fitted with a variable speed governor, so that different speed line characteristics can be taken and also the speed adjusted to account for governor " droop " and ambient temperature. A control panel on the engine includes a tachometer ; an hour meter ; lubricating oil pressure gauge ; exhaust temperature pyrometer ; fuel nozzle pressure gauge ; and fuel control lever.

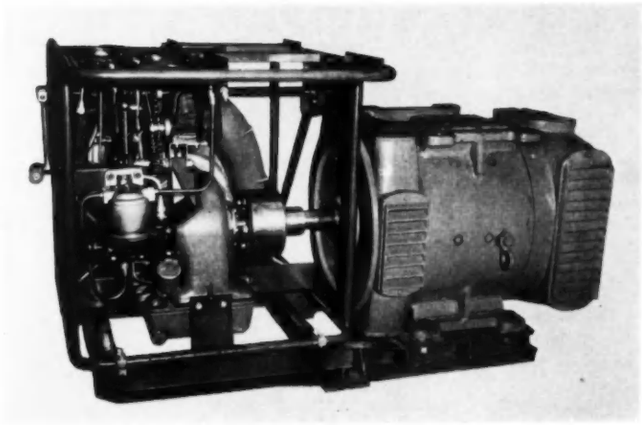


Fig. 54—50 h.p. " Perkins Mars " gas turbine-driven d.c. generator—Perkins

Clarke Chapman and Co., Ltd.

Amongst the new equipment shown by Clarke, Chapman and Co., Ltd., Gateshead-on-Tyne, is an automatic constant tensioning mooring winch specially developed for ships operating in the St. Lawrence Seaway and Great Lakes. No details are available of the design of these winches but it is stated that with them a ship can be held with either constant tension, or moved along the berth, or brought to rest without the use of tugs.

A cargo winch made by the firm for ships with three-phase a.c. supply embodies a tandem squirrel-cage motor consisting of two stators in a common frame and two squirrel-cage rotors on a common shaft. One stator is wound for four- and eight-poles and the other for thirty-two-poles. With this combination three motor speeds are obtained, i.e. approximately 1800, 900 and 225 r.p.m. on a 60-cycle supply. The motor is fitted with an integral disc magnetic brake, and this design of winch has spur reduction gearing—a fixed reduction gear being used for a 3-ton winch and a change speed gear for a 3 to 5-ton winch. The squirrel-cage motor provides controlled lowering speeds of the same order as those obtained for hoisting.

British Manzel Oil Pump Company

On the experimental Doxford " P " range engine a new method for operating the revolution counter was developed by the British Manzel Oil Pump Company, Durranhill Road, Carlisle. The equipment used for this purpose is illustrated in Fig. 55.

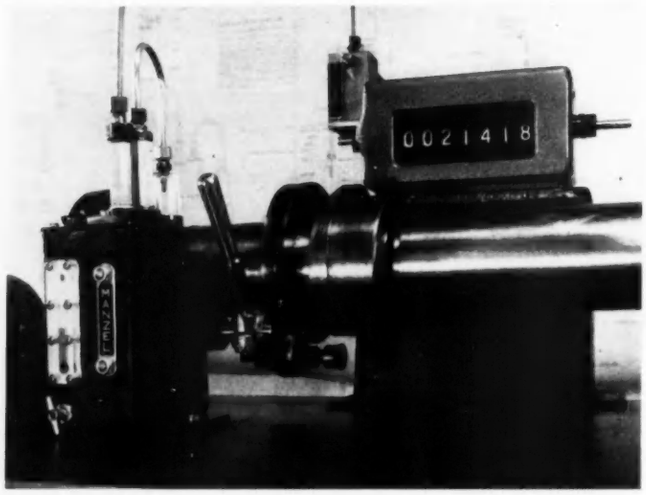


Fig. 55—Oil pump used for actuating the revolution counter lever of a diesel engine—British Manzel

The assembly comprises a pump housed in a steel container and it is operated by a standard Doxford lubricator driving lever working on an eccentric fixed to the camshaft which drives the cylinder lubricators. Each rotation of the eccentric gives an impulse of oil which is pumped through a small bore copper pipe to the counter actuator mounted on the revolution counter at the engine control station.

This impulse of oil ejects a plunger which trips the counter mechanism and by spring return the plunger is withdrawn, automatically returning the working impulse of oil to the pump, ready for the next power stroke. During the power stroke more oil is pumped than is actually required to effect the full movement. This surplus offers a safety working margin which is diverted back to the reservoir via a relief valve set at the pre-determined working pressure. The overspill can be clearly seen for it passes to the reservoir via a transparent sight feed dome.

Drysdale and Co., Ltd.

The two new designs of pumps made by Drysdale and Co., Ltd., Yoker, Glasgow, W.4, are both of positive rotary gear wheel construction. The first, known as the " Axoil " pump is for marine forced lubrication and piston cooling purposes and is made in a range of five sizes to cover outputs from 11·5 to 165 tons an hour and handles oils with viscosities up to 10,000 seconds Redwood No. 1. The pumping element consists of two pairs of rotors intermeshing with one another in the casing bores, the oil flow being in an axial direction from the inlet ports which are arranged at the ends of the casing to the centrally disposed discharge port. The suction and discharge branches are on the centre line of the driving shaft, an arrangement which enables the pump to be turned through 180 deg. when the opposite hand is required.

In addition to the single pump the " Axoil" is manufactured as twin and triple " packaged " sets which comprise two and three pumps, one working and one standby and two working and one standby respectively. The pumps are mounted on common stools and are complete with screw-down non-return suction and discharge valves with associated connecting pipes and fittings. These sets can be installed complete leaving only one suction and one discharge pipe to be connected by the shipbuilder. These packaged sets are available with automatic control gear.

The second new design of pump is for furnace fuel oil pressure feeding and is known as the " Vertoil " Mark II. It is made in a range of six sizes to cover outputs between 560 lb an hour to 66,000 lb an hour with working pressures up to 600 lb per square inch and to handle oils with viscosities up to 6000 seconds Redwood No. 1.

Fig. 56—" Vertoil Mark II " pump for pressure feeding furnace oil—Drysdale

This pump (Fig. 56) is also of vertical mid-mounted design being suspended from the underside of the motor stool. The design and the spur gear rotors enables high pressures to be obtained with hot thin oil.

Short Brothers and Harland, Ltd.

Products from both the electronic and the hydraulic divisions of Short Brothers and Harland, Ltd., Belfast, are shown at Olympia. Two computers to be seen include the new educational analogue equipment which has been developed to meet the trend towards the introduction of computing techniques into the curricula of universities and technical colleges. Although this new analogue equipment is basically intended for an educational instrument the relatively high component accuracy (1·0 per cent) of the computer makes it well suited for laboratory work.

An interesting point in this equipment, which is shown in the photograph

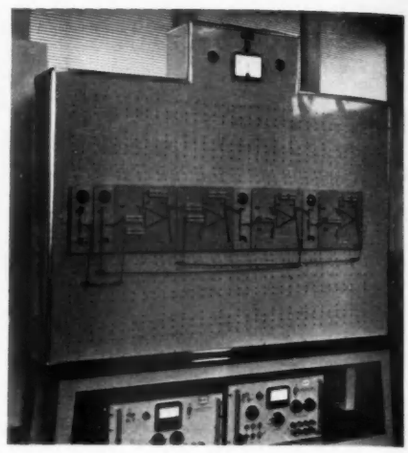


Fig. 57 — Educational analogue computer—Short Brothers

reproduced in Fig. 57 is that as the components required for a particular component are plugged into the simulation base a circuit diagram of the problem is automatically presented on the instrument board.

A one-quarter scale model is shown of a large analogue computer which has been specially developed for the purpose of accurately simulating the behaviour of a complete nuclear power plant. This machine, which has a capacity of 200 amplifiers, is being installed at the Calder Operations School by the United Kingdom Atomic Energy Authority for training operators before they go to work in an actual nuclear power station.

The simulator comprises a console and five racks of equipment and it represents a reactor which, for the purpose of simulation, is considered as being split into three zones. Although this machine is designed to simulate a reactor of the type installed at Calder Hall, a relatively small modification will convert it to simulation of advanced gas-cooled reactors.

A mock reactor control desk similar to those being supplied to new power stations will be used with the simulator. The instruments on the desk will receive their information from the simulator, which will also interpret any control instructions made by the trainee operator and revise its signals to the desk instruments accordingly. Thus the new operator will receive his instruction at a control desk which simulates in all ways one used for supervising the operation of a full-scale nuclear power station. The machine's overall component error, it is stated by the makers, will not exceed one part in 1000.

Imperial Chemical Industries, Ltd.

Two Divisions of Imperial Chemical Industries, Ltd., and a subsidiary company, Marston Excelsior, Ltd., are represented on this firm's stand. The exhibits of the Metals Division and Marston Excelsior, Ltd., are shown in four main groups—nuclear engineering ; titanium ; heat exchangers and heat exchange products ; and general engineering materials. In the nuclear engineering section are examples of zirconium, beryllium, hafnium, niobium and other new metals, and " Boroplast," a boronised plastic material for use in radiation shields, is included in the display. Marston Excelsior, Ltd., show a variety of fabrications for nuclear engineering purposes. Included in a section devoted to heat exchangers and heat exchange products, are a cross section of an aluminium secondary surface heat exchanger with models of a typical installation of such heat exchangers. " Integron " integral finned high-fin and low-fin forms in copper, copper alloy, aluminium and bi-metal which are shown are for use in the electrical, petro-chemical, air conditioning and other industries.

Products of the Billingham Division shown are designed to indicate the uses of both liquid and solid carbon dioxide in industry, and a central exhibit is provided by a standard 5-ton storage tank for liquid carbon dioxide. The use of carbon dioxide for shrink fitting, rubber deflashing, welding and the CO_2/silicate process is described and illustrated on panels.

International Combustion, Ltd.

An exhibit of particular interest to be seen on the stand of International Combustion, Ltd., 19, Woburn Place, London, W.C.1, is a sectioned scale model of one of the two 550MW boilers being built for the Thorpe Marsh power station. Each of these boilers will have an evaporative capacity of 3,750,000 lb per hour at 2400 lb per square inch and 1055 deg. Fah., and they are said to be the largest single units of their kind yet constructed. Following modern conventional practice the steam after passing through the high pressure turbine will be returned to the boiler for reheating to the initial temperature of 1055 deg. Fah. Feed water is delivered into the boiler at a pressure of some 2600 lb per square inch and at 496 deg. Fah. at full load. A more detailed description of these boilers was given in our issue of November 21, 1958.

A display has been arranged to show the Raymond flash drying system which is designed to remove specific amounts of moisture from damp granular or fibrous material. It accomplishes drying under three different conditions : drying with disintegration ; drying without disintegration ; and drying and pulverising. The material is circulated in a hot, turbulent gas stream, causing rapid transfer of heat and evaporation of moisture. A disintegrator or pulveriser is included in the system when simultaneous drying and grinding is required, and the finished product is separated, cooled and conveyed in a dust-free plant operating under suction. Final dryness and particle size of the material are accurately controlled. Hot gas is supplied for the plant either by direct firing, indirect heating or the use of waste gas. The system is used to advantage for drying materials such as wet coal cake and sewage sludge and also for the preparation of chemicals, foods and fertilisers.

A " Dynoscreen " continuous screen design centrifuge for the separation of solids from magmas and slurries in the food, chemical and mining industries is shown in Fig. 58. It can be used either as a centrifuge or a centrifugal screen for separating fibrous or granular solids as well as powdery materials with free draining characteristics. The specific gravity of the solids need not be greater than that of the liquor in which they are suspended to be separated in this machine.

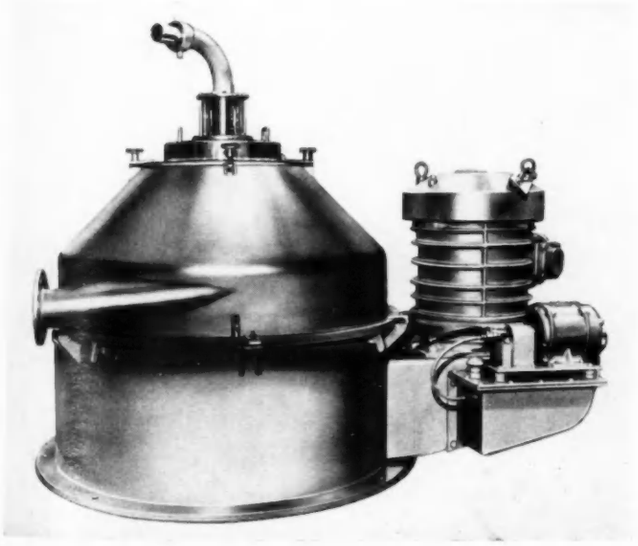


Fig. 58 — " Dynoscreen " continuous screen centrifuge for the separation of solids from magmas and slurries— International Combustion

British United Traction, Ltd.

British United Traction, Ltd., 96, Piccadilly, London, W.1, an associate company of A.E.C., Ltd. and Leyland Motors, Ltd., is to exhibit examples of diesel engines and transmission equipment for installation in railcars, multiple-unit trains and shunting locomotives in addition to a typical industrial shunting locomotive incorporating a vertical diesel engine.

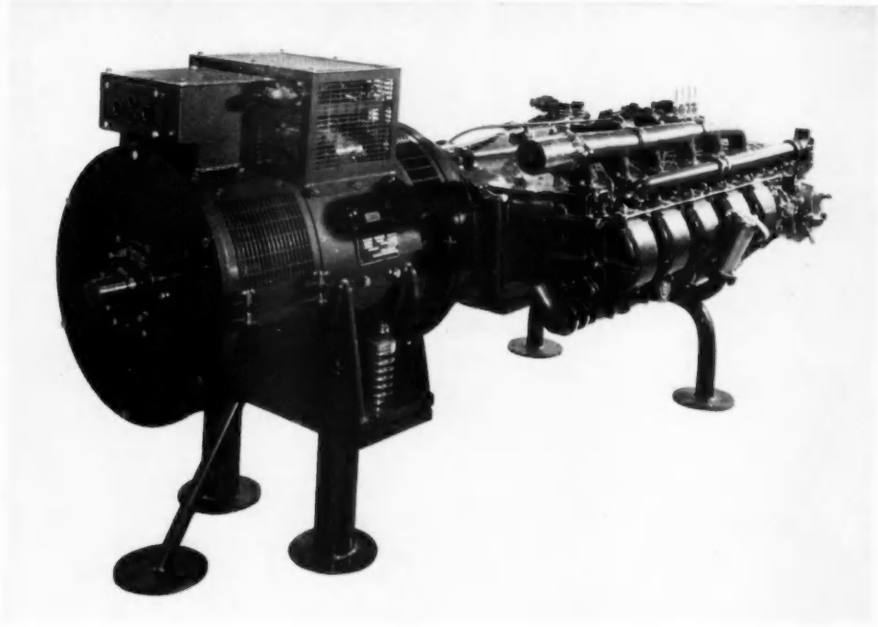


Fig. 59—275 b.h.p. normally aspirated six-cylinder horizontal diesel engine coupled to a generator— British United Traction

This firm's 18-litre normally aspirated six-cylinder horizontal oil engine, is also exhibited complete with an A.E.I. generator as shown in Fig. 59. It develops a maximum output of 275 b.h.p. at 1900 r.p.m. and has a maximum torque of 890 lb feet at 1300 r.p.m. The engine has a monobloc casing and the cylinder liners have an integral ceramic coating to guard against corrosion fatigue. Its six individual cylinder heads have twin inlet and exhaust valves, each pair being actuated by a single rocker. The inlet valves are masked, an arrangement which, together with multi-hole injectors, is designed to produce an intimate swirl mixture of fuel and air resulting in efficient combustion whilst the twin exhaust valves provide adequate scavenging.

The 0-4-0 diesel-hydraulic industrial locomotive shown is a 24-ton standard gauge locomotive typical of the range produced by F. C. Hibberd and Co., Ltd. The power unit is a B.U.T. " 680 Series " six-cylinder, direct injection, four stroke engine. At the governed speed of 1800 r.p.m. this engine develops 163 b.h.p. at one hour rating. A " Twin-Disc " three-stage torque convertor in the transmission incorporates an over-centre clutch for engine isolation purposes and its fluid is taken from the engine fuel system, pressure being maintained by a gear driven pump from the engine.

Lucas Industrial Equipment Ltd.

Pumps and motors for hydraulic systems will provide the main exhibits on the stand of Lucas Industrial Equipment, Ltd., Marston Green, Birmingham, 33.

The range of pumps and motors displayed covers outputs from 60 g.p.h. at 1000 r.p.m. to 3000 g.p.h. at 1000 r.p.m. with maximum operating pressures ranging from 3000 lb. to 5000 lb per square inch. The maximum allowable speeds vary from 6000 r.p.m. for the smallest to 2000 r.p.m. for the largest pumps. When these pumps are used as hydraulic motors they have outputs ranging from 0·75 to 125 horse-power.

The firm's most recent duplex and spill plate type atomisers are now available in a range suitable for fuel flows from 200 lb per hour to 5000 lb per hour. They are calibrated to handle gas oil or heavy fuel oil at different spray angles and are made in stainless steel to provide resistance to sulphur attack, erosion and scaling effects due to flame radiation.

Suspended flame-type boiler registers are made in 10in, 13in and 15in models covering fuel flows from 150 lb per hour to 2000 lb per hour at practical conditions using fuel from 200 seconds to 8000 seconds Redwood No. 1 at 100 deg. Fah. preheated to sixty-eight seconds. It is claimed that the high combustion efficiency of the registers gives a CO_2 value in excess of 14 per cent with no carbon or smut formation. Wide turn-down values are available dependent upon operating conditions and each register incorporates an air slide enabling the operator to establish a non-flash flame. In the engaged position fuel and air are immediately available for correct combustion with further adjustment unnecessary and in the retracted position positive shut-off of fuel and air is obtained.

Metallisation, Ltd.

Exhibits on the stand of Metallisation, Ltd., Dudley, Worcs., have been arranged to show a new development in hardfacing with " Stellite " using the firm's metal spraying pistol (Fig. 60) for application where thin

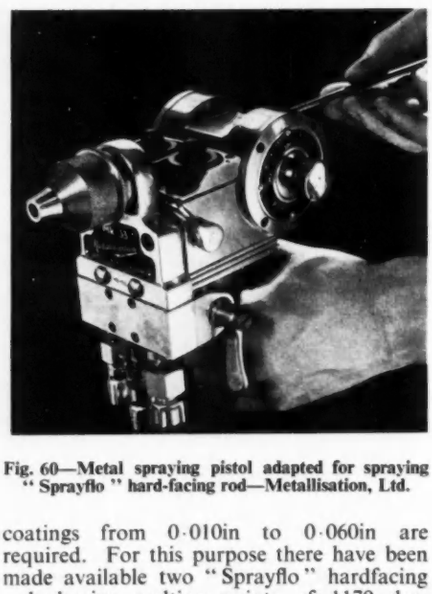


Fig. 60—Metal spraying pistol adapted for spraying " Sprayflo " hard-facing rod—Metallisation, Ltd.

coatings from 0·010in to 0·060in are required. For this purpose there have been made available two " Sprayflo " hardfacing rods having melting points of 1170 deg. and 1140 deg. Cent. with respective hardness factors of 425 and 500 (D.P.H.). It is stated that the material with a melting point of 1170 deg. Cent. has a higher hardness value up to 800 deg. Cent. than any similar quality cast or oxy-acetylene welded " Stellite " deposits. The deposits so applied exhibit the typical structure of sprayed metals but by means of a subsequent fusing operation they are converted to a homogeneous overlay metallurgically bonded to the parent metal. Deposits produced in this way have little variation in thickness and thus demand the minimum consumption of materials and grinding time for finishing. The bond is formed by a diffusion mechanism and analysis shows no detectable increase in iron content even at a distance of 0·006in from the junction.

The process is carried out in three stages—preparation and spraying, which follow general metallising practice, and fusing by which the deposits are subsequently alloyed to the base material by heat treatment. During this fusing operation the deposit is not only metallurgically bonded to the base metal but the deposit itself is transformed from a porous, sprayed condition to an impervious continuous overlay. The standard " Stellite " grades produced for normal welding purposes have been modified to suit the requirements of the " Sprayflo " technique. The three methods of re-melting the sprayed layer used include oxy-acetylene torch fusing, furnace heating in a controlled atmosphere or induction heating. The last two are suitable only for repetition work and mass production where close control of temperatures and time cycles can be applied.

Fluidrive Engineering Company, Ltd.

Several different types of Vulcan-Sinclair fluid coupling made by Fluidrive Engineering Company, Ltd., Worton Road, Isleworth, Middlesex, cover a wide range of powers and duties, from 1/10h.p. to 10,000 h.p. and examples of most of these are exhibited. In the higher power range a Size 22½ double-circuit scoop-trim variable speed fluid coupling shown (Fig. 61) is one of ten sets rated at 5200 h.p. at 3600 r.p.m. being supplied for driving boiler feed pumps at the Lakeview Power Station in Canada. Similar couplings have been supplied for driving 4000 h.p. CO_2 gas circulators for nuclear power generation. The rotating parts of these couplings also being exhibited form part of a number being installed in British power stations, the top rating for this size being 8000 h.p. at 3000 r.p.m.

A sectional model shows the design of a size-18 scoop-control fluid coupling, giving a maximum variable speed regulation of 5 : 1, and other working models on the firm's stand demonstrate the characteristics of the different types of fluid coupling.

Another working model is designed to demonstrate the two main methods of controlling the output of a centrifugal pump, namely by varying the speed with a fluid coupling and, alternatively, by a regulating valve. In it an 8 h.p., 2970 r.p.m. squirrel-cage motor drives a Hayward-Tyler pump by means of a scoop-control fluid coupling and the comparative performance between the two regulating systems is shown by instruments, including flow meter, pressure gauge, wattmeter and tachometer.

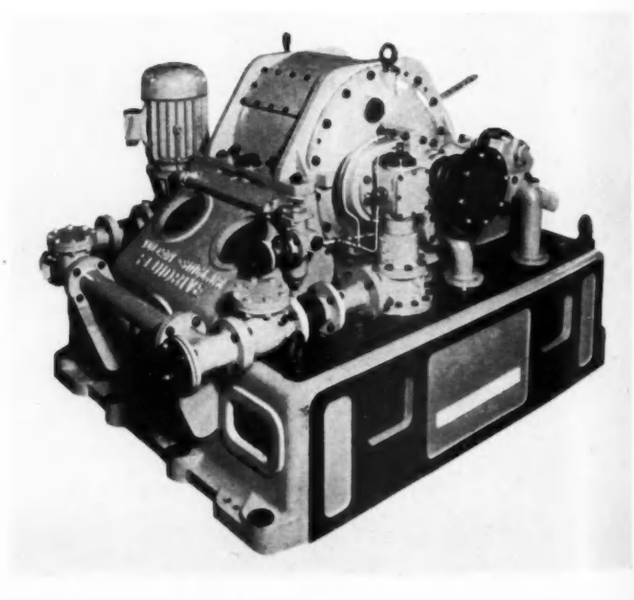


Fig. 61 — Double-circuit, scoop-trim variable speed fluid coupling—Fluidrive

Atlas Copco (Great Britain) Ltd.

A short-stroke, double-acting, stationary air compressor has been introduced by Atlas Copco (Great Britain), Ltd., Hemel Hempstead, Herts, to provide a heavy-duty machine which can be transported in narrow mine shafts and drifts and sited close to headings. By making the piston stroke equivalent to 21 per cent of the diameter of the low pressure cylinder the designers have kept the piston speed down to 10·6ft per second at 970 r.p.m. At this speed the compressor delivers 565 cubic feet per minute at a normal working pressure of 100 lb per square inch. It is driven by a 120 h.p. motor.

For use in small workshops and foundries this company recently placed on the market a two-stage, single-acting compressor with intercooler built for a normal working pressure of 100 lb per square inch and delivering 140 cubic foot per minute. It is driven by a flange-mounted motor, the complete " packaged " unit weighing 1050 lb.

Among a comprehensive selection of pneumatic tools on display are some examples of the " Delta " range of air tools which combine small dimensions and low weight with ample power.

The drills in this range which weigh slightly under 3 lb have air motors developing nearly 0·5 h.p. They have single hand push-grip handles with the feeding pressure in line with the chuck. A new type of five-vane motor fitted has a reserve of power to prevent the drill from stalling when bits break through. The number of parts has been notably reduced in comparison with firms previous pneumatic tools of similar type—the immediate predecessors of the tools consisted of approximately 500 different parts whilst the entire " Delta " assembly incorporates about 250 parts.

Crompton Parkinson (Stud Welding), Ltd.

A new technique for stud welding to aluminium alloys and which minimises porosity and atmospheric contamination has been devised by Crompton Parkinson (Stud Welding), Ltd., Crompton House, Aldwych, London, W.C.2. Tests carried out on the cast metal produced by an aluminium stud weld in the development of the new technique showed that the weld suffered from impurities derived partly from the film of oxide and partly from the residue of a drawing lubricant on the stud, whilst its state was further aggravated by atmospheric contamination imparted during the weld cycle. The problem of contamination has now been dealt with by excluding the atmosphere and substituting argon gas in its place with a special fixture on the gun as shown in Fig. 62.

Fig. 62—Argon shrouded tool used in aluminium stud welding—Crompton Parkinson

The inert gas is introduced and contained in the weld zone by a brass shroud which surrounds the stud and ferrule in the weld position. A valve attachment at the base of the shroud eliminates gas wastage by releasing the argon flow only when the tool is in position. The argon attachment has proved completely successful for aluminium alloy studs up to and including $\frac{7}{16}$in diameter.

On half-inch studs the complete prevention of porosity set a greater problem, and to overcome the slight reduction in strength caused by microscopic porosity the weld base area was, in effect, increased. This was done by making use of the metal displaced when the stud is returned to the molten pool. Investigations showed that fusion did not occur between the displaced metal and the stud sides because the stud periphery was too cold. This led to the development of a preheat arc device, the function of which is to heat the stud to the required temperature immediately before the weld is made. In practice, it is found that a current of approximately 70A and a duration of three seconds give the desired conditions for a $\frac{1}{2}$in alloy stud. With the exception of the argon attachment and the preheat arc device the rest of the equipment used in this process is completely standard.

Also being shown on this stand is a new transformer rectifier which has a maximum output of 4700A and enables $\frac{7}{8}$in diameter studs or shear connectors to be welded at high duty cycles. This unit is of vertically mounted forced-air-cooled design with infinitely variable current adjustment over the range for which it is designed to operate. Integral with the frame of the unit is a small horizontal platform on which a controller may be mounted. This rectifier, although developed primarily for the structural engineering industry will also be of use to firms which have to weld large diameter studs at high rates.

J. Brockhouse and Co., Ltd.

A number of transmission units suitable for a wide range of industrial equipment are made by J. Brockhouse and Co., Ltd., 25, Hanover Square, London, W.1, and one of the firms "F.L.T." equipments for mobile plant is shown in Fig. 63. This transmission

Fig. 63—Dual-speed light reversing transmission with with torque converter—Brockhouse

has an input capacity of 90 lb to 160 lb feet torque and can be used with most well-known makes of internal combustion engines. It embodies a torque converter coupling and an epicyclic gearbox giving one forward and one reverse drive which eliminates the need for a conventional clutch and gearbox. The advantages of a torque converter coupled with a power shift gear change make this transmission eminently suitable for drives where it is required to move heavy loads from rest and where a vehicle is called upon to change direction frequently.

The firm's "I.T.T." torque converter transmission shown on its stand has an input capacity of up to 180 lb feet torque. Though originally designed for Fordson tractor applications to earth moving equipment and heavy duty traction, it has now been adapted to other power units and to other types of equipment. The unit has a power shift gear change, and its two forward and one reverse drive are adequate for most applications. Its high forward gear, incorporated specially to give a high road speed, effects a considerable saving of time when a vehicle is moving from site to site. Four alternative final gear ratios are available, giving a wide range of tractive effort to vehicle speed performance, whilst a live power-take-off and a cooler are optional equipment.

A prototype model of the recently developed "D.S.L." transmission which has been undergoing trials is also exhibited. This unit will be fitted with a torque converter coupling, and will have an input capacity of up to 100 lb feet torque; two forward and two reverse drives; constant mesh gearing operated by hydraulic clutches; and a finger light power shift gear lever. Its front face will match a No. 3 or a No. 4 S.A.E. flywheel housing. The input drive is by ring gear coupling as for a 10in Rockford clutch, and the output drive, by a flange to suit a Hardy Spicer coupling.

Hagan Controls, Ltd.

A boiler control system with pneumatic controls, ring balance meters and a new solid state analogue control system are shown by Hagan Controls, Ltd., 14, Grosvenor Place, London, S.W.1. A typical boiler control system shown in diagrammatic form has the firm's "Ratio Totaliser" as the central computing element for pressures and other variables. The "Ratio Totaliser" consists of three receiving chambers containing sensitive diaphragms, and a transmitting chamber containing a pilot valve and diaphragm. The four chambers are mounted in opposing pairs, the pairs being interconnected by a balance beam carried on a thin sheet steel fulcrum, the position of which is adjustable over wide limits. The output from the relay equals the algebraic sum of the moments of the three input pressure signals.

The ring balance meters exhibited (Fig. 64) operate by evaluating differential pressure caused by a restriction such as a venturi or

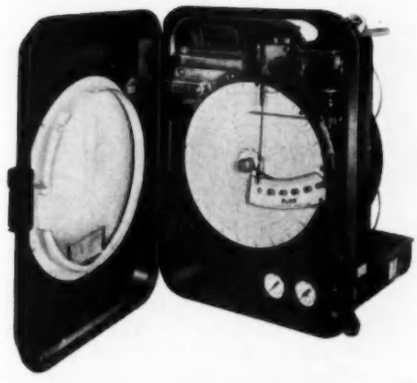


Fig. 64—Ring balance meter for differential pressure measurement calibrated to measure flows up to 100,000 lb. per hour—Hagan Controls

orifice plate in the line of flow. An individual meter can be used for measuring pressure differential of any type of fluid within the range of the ring assembly and without any major changes to the meter. Flow range adjustments of 2 : 1 can be made on site without modifying the primary element or disconnecting meter piping. The instrument accuracy, is stated to be within $\pm 0{\cdot}5$ per cent of full scale from 100 per cent to 10 per cent of scale ranges, with useful indications below the 10 per cent value.

The analogue computer control systems, known as "PowrMag" systems, made by the company are designed to complement digital computer control, and employ magnetic amplifiers in an electric analogue technique. The applications include centralised plant or multi-plant control and systems requiring direct tie-in with data processing equipment.

Hydraulics and Pneumatics, Ltd.

A hydraulically powered operating unit for the large valves used on modern tankers has been developed by Hydraulics and Pneumatics, Ltd., Villiers Street, Wolverhampton.

In contrast to the usual method using hydraulic cylinders mounted directly on the valves and controlling them from a remote point through selector valves directing oil to either side of the hydraulic piston, the system developed by Hydraulics and Pneumatics, Ltd., operates on a pressure ring system. This system is stated to avoid the necessity to run separate pressure and return lines to each valve from the control point and enables considerable reduction in the cost of piping to be made.

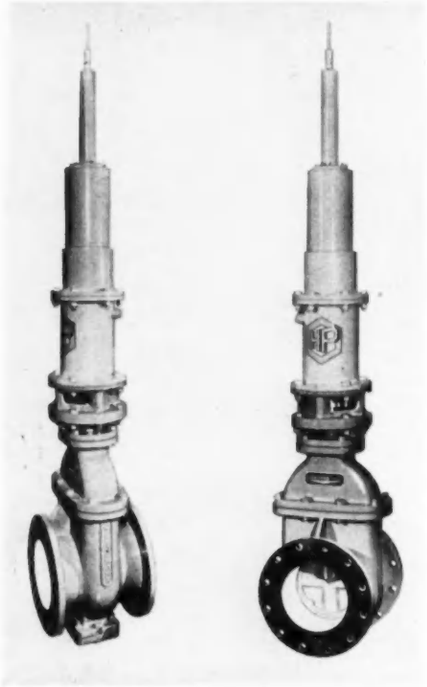


Fig. 65—Large tanker valve fitted with hydraulic actuator—Hydraulics and Pneumatics

The operating unit, to be seen on a valve in Fig. 65, is an extension of the firm's standard hydraulic positional servo actuator design employing a cable control system which also shows the actual degree of opening of the tanker valve. It enables an operator to gradually close down the valve whilst having full knowledge and control of the degree of opening. A further development of this firm's hydraulic positional control servo actuator, is a marine steering system for small fishing vessels. In this system the ship's wheel drives, through a step-up gear, a duo-directional transmitter which displaces hydraulic fluid along the transmission pipes between the wheel house and the stern of the vessel. This fluid moves the pilot cylinder, causing the actuator to move with a magnified force and position the ship's rudder at the selected angle—a low effort transmission is thus converted into an amplified output. Power for the equipment is provided by a variable delivery hydraulic pump.

In the event of hydraulic power failure provision is made for automatic change over to manual transmission to allow steerage to be maintained from the wheel house at a somewhat slower response rate. No form of mechanical transmission is required between the wheel house and the stern of the vessel, the only connection being three small hydraulic pipes. It is stated that no drift of the rudder can occur as it is hydraulically locked in the selected position and no oil flow takes place during steady conditions.

Marshall Sons and Co., Ltd.

As their main exhibit Marshall Sons and Co., Ltd., Gainsborough, are showing a "Cleaver-Brooks" CB125 packaged boiler (Fig. 66) rated at 4310 lb steam per hour from and at 212 deg. Fah. It is a typical unit from the wide range made by the firm and which includes boilers from 1380 lb to 20,700 lb steam per hour.

The four-pass horizontal firetube boiler exhibited has five square feet of heating surface per rated boiler horse-power and is designed to burn any grade of fuel oil or gas. Mounted on a heavy steel frame, it is pre-assembled for immediate installation and factory tested ready for attachment of water, steam, fuel, electrical and vent connections.

Both front and rear heads of the boiler can be swung open to expose the tubes and fire side surfaces for inspection and servicing. The air atomising burner, forming an integral part of the front head, can be removed quickly for cleaning. Also located on the front head is a forced draught blower providing secondary air for combustion, and the controls which are contained in a dust-proof panel.

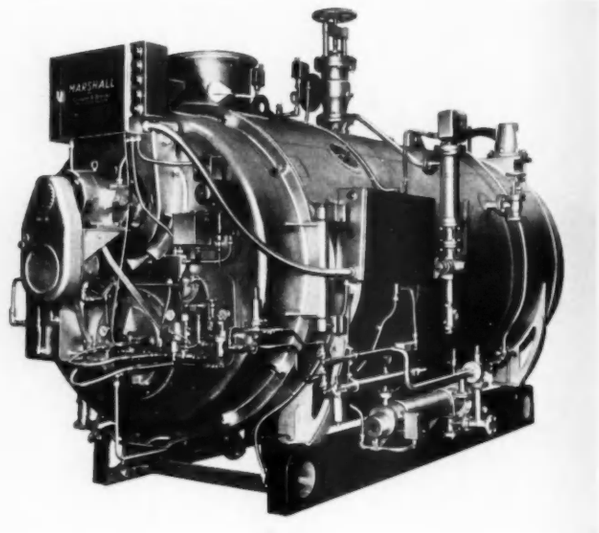


Fig. 66—Packaged boiler rated at 4310 lb of steam per hour. This boiler is factory assembled, delivered ready for operation on connection to service and power lines—Marshall

Saturn Industrial Gases, Ltd.

An equipment, known as the "Seirion," has been introduced by Saturn Industrial Gases, Ltd., Erl Wood, Windlesham, Surrey, for use with a d.c. welding power source to initiate the arc without need for making contact between the electrode and workpiece. The instrument is intended specifically for the welding of stainless steel, nickel chromium alloys, copper and copper alloys by the inert gas process.

With this equipment arc-starting is automatic and immediately the arc has been established the starting pulse is automatically switched off to be restored instantly on arc failure. Water and argon supplies for the torch are passed through the set and the welding current and argon supply are brought into operation by a switch incorporated in the torch handle. Welding on site or where and a.c. main supply is not available, is possible, as the starting pulse derives its power from the welding generator and is not dependent on an a.c. mains supply.

Laurence Scott and Electromotors Ltd.

A selector self-contained d.c. cargo winch shown by Laurence, Scott and Electromotors, Ltd., of Norwich, is the self-contained version of the winch supplied originally by the firm with the contactor gear arranged for deck-house mounting. The control gear is accommodated in a compact weatherproof case forming part of the winch assembly.

The winch provides a full load speed of 100 f.p.m., rising to 350 f.p.m. with light hook, the maximum speed being limited to a safe value by a "load-weighing" means. In addition to electrical braking, a friction brake is provided for holding the load only and for emergency use. This winch is supplied in 3 and 5 ton ratings, for direct or remote control.

A corrector self-contained cargo winch for use on ships with a.c. mains also being shown incorporates a light-weight motor generator set, supplying the winch motor on the Ward-Leonard variable-voltage system. The machine provides a flexible control, a high rate of acceleration, and a wide speed range without gear change.

Worthington-Simpson, Ltd.

Exhibits being shown for the first time by Worthington-Simpson, Ltd., of Newark, Notts., include a cargo oil pump, a high head centrifugal pump, an open impeller "Monobloc" pump, a sump pump and a 1½in "Vortex" pump.

The "Monobloc" pump is one of a range specially designed to handle slurries, liquids containing small solids, and viscous liquids up to about 1000 seconds Redwood No. 1. When used for pumping water these pumps have a maximum capacity of 360 g.p.m. and a maximum head of 86ft.

The sump pumps, which are designed to run at 2900 r.p.m. and are driven by motors from 1½ to 10 h.p., are intended for use in sumps up to 10ft deep. The range covers capacities up to 330 g.p.m. with heads up to 210ft depending upon capacity. A variety of acids, alkalis and slurries can be handled and some of the pumps will handle solids up to ½in diameter.

The air compressing equipment made by the firm is represented by a two-stage rotary oil-cooled compressor with a displacement of 600 cubic feet per minute and reciprocating compressors with single-, two- and three-stages.

Ruston and Hornsby Ltd.

Among the exhibits on the stand of Ruston and Hornsby, Ltd., is a five-cylinder A.T. engine which is pressure-charged and inter-cooled and rated at 835 s.h.p. at 500 r.p.m. This mark of engine is available with five-, six-, seven-, eight-, or nine-cylinders and develops from 622 to 1420 b.h.p. at 500 r.p.m. The bore is 12½in and the stroke 14½in and when turbo-charged the brake mean effective pressure is 125 lb per square inch, the corresponding pressure for the inter-cooled unit being 160 lb per square inch and the maximum cylinder pressures for the respective units being 1000 lb and 1200 lb per square inch. Fuel is injected at 2500 lb per square inch and there are four valves per cylinder.

Fig. 67 — 12YJCL vee-form, twelve-cylinder, pressure charged and inter-cooled engine—Paxman

Also exhibited is the turbo-charged 6YEXM which has been developed from the YE range of engines. This is a four-cycle direct injection engine having six cylinders of 5in bore by 5⅞in stroke and developing 175 b.h.p. at 1800 r.p.m. and using a single-stage centrifugal blower driven by an exhaust gas turbine. As shown the engine has a 3 to 1 reverse reduction gearbox consisting of two oil-operated clutches, multi-bronze and steel plates for ahead drive and a cone clutch with fibre lining for the astern gear which consists of an epicylic gear train. Another unit on show is the two-cylinder YWAH air compressor set in which one cylinder of a two cylinder 2YWA engine is replaced by a Hamworthy air-cooled single-stage air compressor. It is capable of a free air delivery of 15 cubic feet per minute at 350 lb per square inch or 18·5 cubic feet per minute at 200 lb square inch. A 30in Ruston-Grayloc pipe connection can be seen and is designed for use where liquids and gases at high pressures and temperatures are involved.

Three engines in the Paxman range are shown and include a Mark 8YGAXM fitted with a Self-Changing Gear Company's reverse/reduction gearbox and rated to develop 320 s.h.p. This is an air-cooled engine with the cylinders in 90 deg. V form and having a bore of 6in by 6·6in stroke and a compression ratio of 15 to 1. A larger engine is the 12YJCL pressure charged and inter-cooled engine, illustrated in Fig. 67. It has a bore and stroke of 7¾in by 8½in, a firing pressure of 1250 lb per square inch and a continuous rating of 1400 b.h.p. at 1500 r.p.m. The crankcase and cylinder blocks are of fabricated monobloc construction, with liners chromium plated internally and externally. Two inlet and two exhaust valves are carried in the high strength aluminium alloy cylinder head. Monobloc C.A.V. fuel injection pumps are provided for each cylinder bank. The third Paxman exhibit is a marine auxiliary generating set powered by a Mark 8RPHCZ pressure charged engine of 420 b.h.p. rating and one of the company's long established 7in bore range of engines.

Hawker Siddeley Industries, Ltd.

Mirrlees, Bickerton and Day, Ltd., a member firm of Hawker Siddeley Industries, Ltd., has on its stand a KVSS16 diesel engine which we show in Fig. 68. This is a four-stroke, direct-injection, exhaust turbo-charged and inter-cooled unit having sixteen cylinders arranged in two banks of eight set at an included angle of 45 deg. The bore and stroke are 15in and 18in respectively and the engine, which will be installed in the Tema Harbour power station, has a site rating of 4159 b.h.p. at 428 r.p.m. For this mark of engine the general power rating is 2880 b.h.p. at 300 r.p.m. to 4320 b.h.p. at 450 r.p.m. Other main particulars of the engine are : maximum pressure 1080 lb per square inch ; brake mean effective pressure 150 lb per square inch ; mechanical efficiency 87 per cent ; thermal efficiency 41 per cent ; fuel consumption 0·336 lb per b.h.p. per hour ; and length, breadth and height are 30ft 6in by 15ft 6in by 10ft 8in. The bedplate is of cast iron construction and the column, which forms the upper half of the crankcase is robustly built and carries the cast iron cylinder casings. The cast iron pistons fitted are arranged for oil cooling, the oil being fed via crankshaft and connecting rod, the former being machined from a solid steel forging while the latter is an En.8 heat treated steel forging. There are two exhaust and two inlet valves in each cast iron cylinder head and the cylinder liners, of close grained cast iron, are fixed at the top and free to expand downwards. Individual plunger pattern fuel pumps are mounted at each cylinder and a gear pump delivers lubrication oil under pressure to the engine. Cooling is by a closed circuit fresh water system.

Exhibited by the National Gas and Oil Engine Company, Ltd., is a Mark R4AG8 alternative fuel, spark ignition engine, having a bore of 9in by 12in stroke, coupled to a 260kW Brush alternator. The engine is arranged to run on gas and develops 364 b.h.p. at 600 r.p.m. It can be converted to run on oil, by fitting fuel pumps and injectors, &c., when 402 b.h.p. will be developed. This mark of engine is available with three to eight cylinders and normally aspirated, pressure charged or pressure charged and inter-cooled. Column and bedplate are cast in one piece and the cast iron cylinder heads have two inlet and two exhaust valves. The pistons have four pressure and two scraper rings and the connecting rods are alloy steel stampings while the crankshaft is

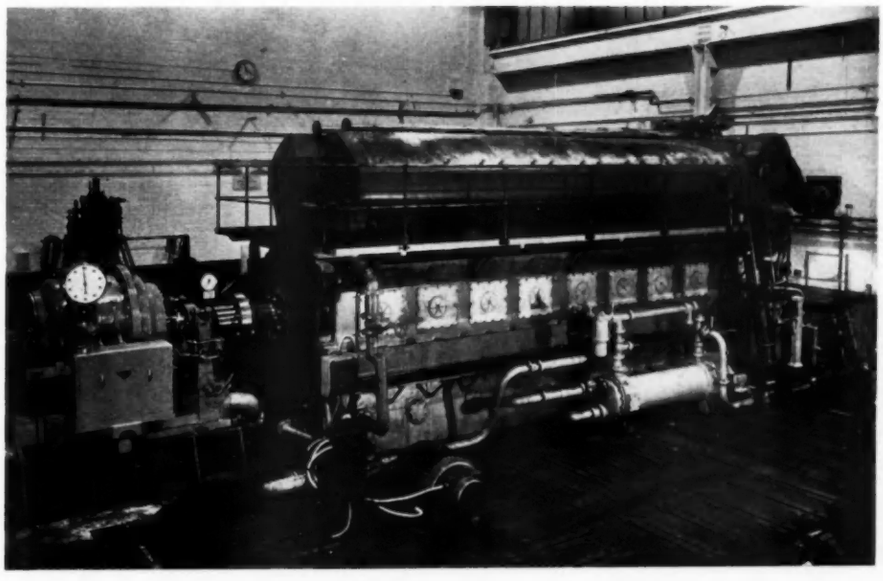


Fig. 68—KVSS16 diesel engine on test bed—Mirrlees

machined from 40 tons to 50 tons carbon steel.

A FM5 marine engine which is also on view is a five-cylinder normally aspirated unit, of 12in bore by 15in stroke ; developing 475 b.h.p. at 500 r.p.m. It has a brake mean effective pressure of 88·5 lb per square inch and is coupled to a M.W.D. 3 to 1 reverse-reduction gearbox. This mark of engine is available with three to eight cylinders, covering the power of 285 to 1550 b.h.p. at 600 r.p.m., and normally aspirated, pressure-charged or pressure charged and inter-cooled. The company also shows a working scale model of a "Sovereign" marine diesel engine which has a bore and stroke of 12in by 15in and a compression ratio of 13 to 1 normally aspirated and 12 to 1 when turbo-charged. The engine is available with six, seven or eight cylinders and covers a power range from 342 to 1372 b.h.p. over the speed range of 300 to 600 r.p.m.

A schematic control panel illustrates the Brush electrical propulsion system as installed in the diesel-electric tug "Llanwern" and Hawker Siddeley Brush Turbines, Ltd., shows examples from a range of six turbo-chargers with free air capacities from 960 cubic feet per minute to 24,400 cubic feet per minute. Another member of the group, Petters, Ltd., is showing six diesel propulsion units and one auxiliary set from its range of low power engines. The B4 marine diesel auxiliary set incorporates a B4 water-cooled diesel engine, a 15kW generator, a water-cooled compressor and a single stage centrifugal pump.

British Oxygen Company, Ltd.

Demonstrations have been arranged by the British Oxygen Company Ltd., Bridgewater House, St. James's, London, S.W.1, to show the latest techniques and important advances in the production and distribution of industrial liquids and gases. In addition to a model of an oxygen producing plant there is also shown one of the firm's latest vacuum insulated evaporator vessels for liquid oxygen storage. These evaporators have been developed in connection with a

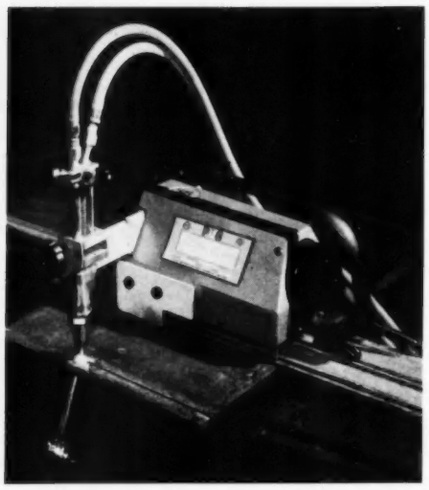


Fig. 70—Portable lightweight oxygen cutting machine which cuts and bevels steel up to 2in. thick and cuts circles from 3 to 45in. diameter—British Oxygen

programme for modernising, improving and extending liquid oxygen distributing and dispensing equipment under which tankers, fitted with electrically driven pumps, deliver liquid into an evaporator in consumers' works at a pressure up to 300 lb per square inch. With the introduction of the new vacuum insulated evaporators, existing cold evaporators are being modified to take pressure filling, the system is to be extended to include liquid nitrogen and liquid argon.

With these new and modified evaporators, fresh supplies of liquid can be pumped in without interruption of customer's demand, the pump filling operation being twice as fast as the conventional decanting method.

With these pressure filled systems a plant is entirely automatic and maintains a pre-determined pipeline pressure. The increased efficiency of the insulation, in general, increases storage capacity and evaporators can be installed in the open without need for special buildings.

A noteworthy plant made by British Oxygen Company, Ltd., is the "Eagle" computer-controlled cutting machine for plates, which is illustrated on page 629. The machine incorporates the Ferranti control system and can cut two plates at the same time—each plate being up to 40ft long, 12ft wide and 3in thick. Our photograph shows the machine undergoing tests before it was installed in the Wallsend shipyard of Swan, Hunter and Wigham Richardson.

The "Argonarc" welding equipment includes a new spot welding torch designed for use by semi-skilled labour. With this torch welding conditions are preset and the process is semi-automatic—only occasional changing and resetting of the tungsten electrode being required. The torch, which is water-cooled and can carry currents up to 300A, is switched on by a button micro-switch in the handle. With interchangeable nozzles the torch can be used for making spot welds in horizontal or vertical positions, on narrow flanges, or on 90 deg. outside corner joints.

A portable lightweight oxygen cutting machine (Fig. 70) recently introduced, which is known as the "Pug" and weighs only 21 lb. It is designed to cut and bevel steel up to 2in thick and cut circles from 3in to 45in in diameter. It runs on an extensible light alloy track and can be used to make straight cuts of any length, an adjustable trammel attachment being used for circle cutting. The cutter can be moved through any angle up to 45 deg. for bevelling, and has means of vertical and lateral adjustment. The operational speed range of the machine is 10ft to 180ft an hour, using a rotary resistance speed control. Its maximum power consumption is 80W.

A new automatic line following device demonstrated on the firm's latest "Bison" profile cutting machine is shown in Fig. 69. This device profile cuts from ink or pencil line drawings, no templates being required and the same drawing can be used for cutting any thickness of steel. Automatic compensation for kerf width is made by simple dial setting. Printed circuits and transistors used in this equipment ensures reliability and an optical scanning head with stationary photo-transistor cell eliminates the fatigue hazards of conventional vibratory photocell systems.

The new British Oxygen "MRCS.300" slope-controlled rectifier exhibited is available in 150A, 300A and 500A capacities. With this new rectifier semi-automatic electric welding of mild steel over a wide range of thicknesses down to 20 S.W.G., in any position, and even with excessive gaps is stated to be possible.

It incorporates a slope control essential for thin gauge welding where the "short-circuiting arc" technique is used. This slope control is designed to produce a volt/ampere curve enabling the operator to select any characteristic between constant potential and steeply drooping to suit any welding position. A closely controlled arc gives a pin-point heat source.

(*To be continued*)

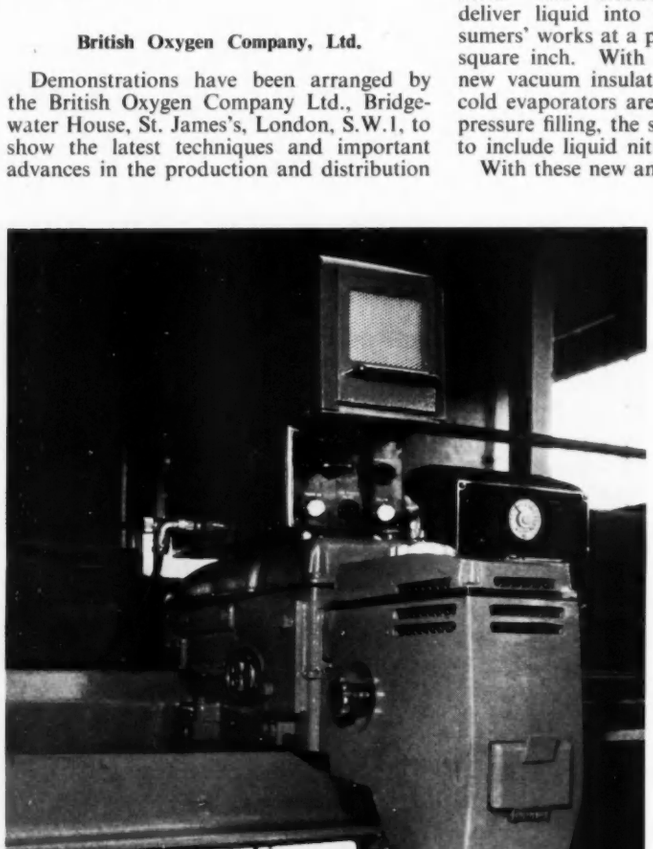


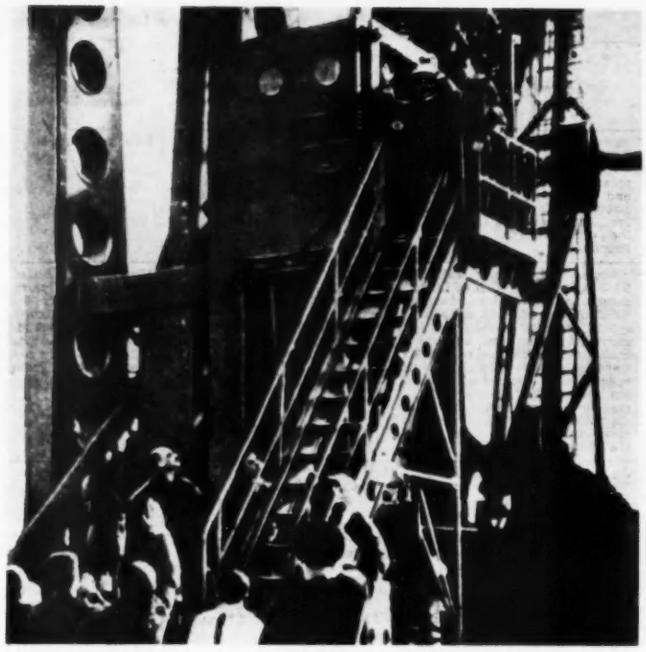
Fig. 69—Automatic line follow-device which is used for profile cutting from ink or pencil line drawings. Automatic compensation for kerf width is made by dial setting—British Oxygen

Rockets and Space Flight, 1960

By JOHN E. ALLEN*

No. III—(*Concluded from page 608, April 14, 1961*)

Progress during the first year of a new decade—which will be the first complete decade of space flight—is being reviewed under the headings of rocket propulsion systems, rocket propelled vehicles (including satellites and space probes), and man-in-space. Future trends, as shown by such details as have been released, are indicated wherever possible. Right: Major Gagarin (in helmet) immediately prior to his orbital flight



MAN IN SPACE

As details of most aspects of the American man in space programmes have been published elsewhere, such as the X-15 rocket aircraft for fringe flight, the "Mercury" manned orbital capsule, and the manned "Dyna-Soar" military winged orbital vehicle, this review is confined to 1960 developments.

Russian Activity.—At the time of the Pacific rocket launchings announcement, space projects reviewed by the Soviet press included the Khlebtsevich plan of 1955 for a 1100 lb robot tank for lunar exploration, and the Petrovich manned version of the same scheme. Professor Vladimir Dobronravov has said that the following problems should be solved within the 1960's :

(1) Artificial satellite of the Moon ;
(2) Space rocket orbiting close to Mars or Venus ;
(3) Recoverable Earth satellites ;
(4) Manned flight in recoverable Earth satellites ;
(5) Manned flight to the moon.

Item (3) has been achieved by "Sputnik 5," as already noted, and it would appear that (4) is the next step. At present, however, it seems likely that the U.S.S.R. may attempt three "firsts" soon : a July, 1961, launching of an instrumented probe towards Venus ; an early launching of a manned orbital capsule similar to "Sputnik 5"; and a robot vehicle for lunar exploration perhaps in 1962 or later. However, if these attempts are made as official world records, they may not come as so much of a surprise as previous Russian launchings, for in November, 1960, the Fédération Aéronautique Internationale announced the formulation of some new rules. These rules say that the flight plan for world records in outer space must be submitted to and approved by the F.A.I. prior to the record attempt, and that the event must be verified by instrumentation sanctioned and approved by F.A.I.†

X-15 Rocket Aircraft.—The second X-15 rocket aircraft vehicle made its first successful flight with the new XLR 99-RM-1 engine with a thrust at sea level of 50,000 lb, on November 15, reaching 2000 m.p.h. and over 65,000ft. The first X-15 has two XLR-11 engines which develop a total of only 16,000 lb thrust (Fig. 25). This test was closely followed by a flight on November 22 to check the engine's stop/start capability. Since then, the long sharp nose has been modified. A spherical nose, called a "Q-ball," fits into the forebody to give a hemispherical profile. The Q-ball contains an air stream direction sensor together with a hydraulic servo system to keep the sensor port in line with the direction of flow. The pilot's indicator shows the attitude angles of the aircraft to the flow ; this is valuable information needed to correct attitude during re-entry, thus avoiding rapid overheating. An illustration and some notes on this device have already appeared in the January 13, 1961, issue of THE ENGINEER, page 37. On the first Q-ball flight the craft attained 1254 m.p.h. and about 50,000ft altitude.

Previously, on August 12, the X-15 reached its unofficial altitude record for the year, climbing to 131,000ft—the highest flight of a manned aircraft—after release from a B-52 bomber at 45,000ft. Major Robert White became weightless for a few seconds at the apex of the climb, but much longer periods are needed for space medical research. Later the aircraft landed on its steel skids at a speed of 200 m.p.h. The maximum performance is expected to give speeds of over 3600 m.p.h. and altitudes of more than 100 miles.

"Mercury."—The "Mercury" programme has been delayed by a number of setbacks. As explained in Reference 1, the object is to send a man into space in the "Mercury" capsule and achieve successful recovery after re-entry. Unfortunately, the first test launch with "Atlas" as booster failed in July, when the "Atlas" exploded : this had been intended to gauge the ability of the production version of the capsule to withstand entry at a steep angle. A "Little Joe" test capsule firing also failed, in November. The first "Mercury"–"Redstone" launching (Fig. 27) into a ballistic trajectory on December 19, however, was a success, and the only apparent damage to the capsule found on recovery from the sea was a broken outer layer of the three-layer heat-

Fig. 25—An X-15 in course of attachment to a B-52 ; the lower part of the ventral fin has yet to be fitted. This machine has the early eight-chamber rocket engine

* Member, American Rocket Society ; Member of Council British Interplanetary Society.

† Claims for recognition as world records have in fact been made for the orbit of Major Yury Alexevich Gagarin in the spaceship "VOSTOK" on April 12.

TABLE II(*a*).—*Satellite and Probe Launchings during* 1960 (*see separate Table* II(*b*) *for "Discoverer" series*)

Name and description	Launching rocket	Launch date and estimated lifetime	Main purposes and results	Orbit			
				Perigee height (miles)	Apogee height (miles)	Period (minutes)	Inclination to equator (deg.)
"Midas 1" (Missile Defence Alarm System). Satellite consisted of "Agena" A rocket, with instrumentation which included infra-red and telemetry equipment, and power supplies. Cylindrical, 22ft long, 5ft diameter. Total weight for orbit 4500 lb. (U.S.A.F. direction)	U.S.A.F. "Atlas-Agena" A. Launch weight: 260,000 lb. Dimensions: 99ft high, 16ft diameter base. Two stages: (1) Modified "Atlas" ICBM (2) "Agena" A	February 26 (failed)	Feasibility test of a system for detecting ICBM launchings with satellite carrying infra-red sensors	"Agena" A failed to separate. Burned upon re-entry after 2500 miles			
•"Pioneer 5." Solar satellite. 94·8 lb, including 40 lb of instruments for measuring plasmas, radiation and charged solar particles, magnetic fields, micrometeorite impact, and an aspect indicator. One 5W and one 150W transmitters were carried. Power supply from 4800 solar cells charging twenty-eight small nickel-cadmium batteries. Sphere, 26in diameter with four paddle-shaped vanes to carry the solar cells. (N.A.S.A. direction)	U.S.A.F. "Thor-Able." Launch weight: 150,000 lb. Dimensions: 90ft high, 8ft diameter base. Three stages: (1) Modified "Thor" IRBM (2) Modified "Vanguard" (liquid engine) (3) Modified "Vanguard" (solid engine)	March 11. Life of about 100,000 years. Transmission life 106 days (last message received Jodrell Bank on June 26.) Probably not near the Earth again until 1989	To explore the regions of space between the orbits of Mars and Venus, providing data on radiation, plasmas and charged solar particles, micrometeorites and magnetic fields *Results:* Successful provision of data, especially during the intense solar flare activity during the early part of its flight. Transmission maintained until vehicle reached a distance of 22·5 million miles	74·9 million (perihelion)	92·3 million (aphelion)	311·6 days	3·35 deg. to Ecliptic
"Explorer" (no number, but see "Explorer" 8). Research satellite. Fourth stage casing with 22·8 lb instrument package, including radiation counters and temperature measuring instruments, telemetry, solar cells and batteries. Cylindrical, 21in long, 9in diameter Total weight for orbit 35·3 lb. (N.A.S.A. direction)	U.S. Army "Juno" 2. Launch weight: 120,000 lb. Dimensions: 76ft high, 8ft. diameter base. Four stages: (1) Modified "Jupiter" IRBM (2) Eleven scaled-down "Sergeants" (3) Three ditto (4) One ditto	March 23 (failed)	Intended for highly elliptical orbit, to measure electron and proton energies in the radiation belts	Failed—fate unknown; not tracked after second stage burnout			
•"Tiros 1" (Television Infra-red Observaton Satellite). Meteorological satellite. 270 lb, with cameras, recorders, receiver and transmitters, beacons, batteries. Top and sides occupied by 9200 solar cells. Equipped with spin rockets and other devices for spin-stabilisation. Pillbox shape, 19in high, 42in diameter, aluminium and stainless steel structure. (N.A.S.A. direction)	U.S.A.F. "Thor-Able," as for "Pioneer 5."	April 1. Up to 100 years expected. Data was transmitted until June 17 (78 days)	Feasibility test of television techniques for gathering meteorological data *Results:* Near-circular orbit achieved. Over 22,000 cloud-cover pictures relayed during transmitting life	429·7	467·4	99·2	48·3
•"Transit 1B." Navigation satellite. 265 lb, including infra-red scanning device to measure rotation speed, transmitters, batteries and solar cells. Sphere, 36in diameter, glass fibre structure. (U.S. Navy direction)	U.S.A.F. "Thor-Able-Star." Launch weight: 105,000 lb. Dimensions: 97ft high, 8ft diameter base. Two stages: (1) Modified "Thor" IRBM (2) "Able-Star" liquid engine with re-start capability	April 13. Six years in orbit. Transmission life about three months	Experiment on feasibility of navigation satellites to transmit data to ships and aircraft *Results:* Feasibility established. "Able-Star" was the first rocket to be shut-down and re-started in space	233	479	96	51
"Echo 1" (first attempt). Passive communications satellite. 132 lb of aluminium "Mylar" film, containing sublimating powder for inflation. Folded and packed into a 26·5in diameter magnesium sphere carried in the third stage casing. Inflatable to 100ft diameter. (N.A.S.A. direction)	U.S.A.F. "Thor-Delta." Launch weight: 112,000 lb. Dimensions: 92ft high, 8ft diameter base. Three stages: (1) Modified "Thor" IRBM (2) Modified "Vanguard" (liquid engine) (3) Modified "Vanguard" (solid engine)	May 13 (failed)	To place a reflector sphere in a 1000-mile orbit, capable of 98 per cent reflectivity up to 20,000 Mc/s, for passive communications experiments	Failed to reach orbit. This was the first use of "Delta": the second stage control was faulty, and the third stage did not ignite			
•"Sputnik 4." Experimental spacecraft. 10,008 lb total, with pressure cabin of 5512 lb plus 3230 lb of instruments. Said to contain a "dummy astronaut" and an environmental control system. (U.S.S.R.)	No details issued, but probably 1,000,000 lb thrust. (The rockets tested in the Pacific were probably between 800,000lb and 1,000,000 lb thrust)	May 14. Two to three years	To test life support equipment and recover the space cabin from orbit *Results:* Near-circular orbit achieved. Space cabin separated from satellite, but was wrongly oriented at time of retrorocket firing, and went into a slightly higher orbit instead of re-entering	188·5 191	228·7 (after retrorocket firing) 429	91·1 94·25	64·9
•"Midas 2"—as for "Midas 1,' but total weight in orbit was 5000 lb. (U.S.A.F. direction)	U.S.A.F. "Atlas-Agena" A as for "Midas 1"	May 24. Orbital life of up to fifteen years estimated. Transmitted data for two days	As for "Midas 1," but initial aim was to obtain an infra-red picture of Earth from 300 miles altitude. *Results:* Feasibility partly established, but telemetry link ceased operating much earlier than expected, and the required picture was not obtained	300	313	94·3	33
"Transit 2A." Navigation satellite, plus "piggyback" NRL "Greb" satellite. •2A: Similar to "Transit" 1 but completely solar-powered, and carried electronic clock to provide time signals. Also carried a Canadian receiver for measurement of galactic radio noise. Sphere 36in diameter. Total weight in orbit 223 lb •*Greb:* Research satellite by NRL. 42 lb, including radiation instruments, battery plus solar cells. Sphere 20in diameter. (U.S. Navy direction)	U.S.A.F. "Thor-Able-Star," as for "Transit 1B"	June 22. Fifty to 200 years in orbit estimated for both, with transmission for up to one year	2A: as for "Transit" 1B, plus provision of accurate time standard. *Greb:* Solar radiation data *Results:* Both transmitting and orbiting separately. This was the first time two satellites were launched together successfully	389 382	650 667	101·6 101·6	66·7 66·8
•"Echo 1" (second attempt). Passive communication satellite—as for first attempt of May 13, with the addition of two tracking beacons attached to the sphere and designed to transmit as long as spherical shape retained. Beacons powered by solar cells and batteries. (N.A.S.A. direction)	U.S.A.F. "Thor-Delta" as for "Echo 1"	August 12. Possibly up to ten years in orbit, but at present being pushed closer to Earth by solar radiation	As for first attempt. *Results:* Successful use for various passive communication experiments	945 620	1049 (After severe solar flare at beginning of November orbit became: 1316	118·3 117·2	47·2

• Still in fall.

resistant glass in the port-hole. A total of twenty-four capsules has been ordered from McDonnell Aircraft Corporation, and after the delays the overall cost of the programme may far exceed N.A.S.A.'s present estimate of 350 million dollars—which already has exceeded the original figure of 200 million dollars.

A second "Mercury"–"Redstone" launching was made on January 31, 1961, successfully carrying a chimpanzee on a ballastic flight, and effecting live recovery from the sea. The "Mercury" capsule was sent up to 155 miles—40 miles higher than was expected—and landed about 420 miles down range instead of 290 miles, these errors being due to unusually high booster thrust. This should be closely followed by the second and other "Mercury"-"Atlas" firings, and a "Mercury"–"Redstone" manned ballistic flight may now be made by March. N.A.S.A.'s 1961 programme lists sixteen "Mercury" launchings, including one "Little Joe" test, six "Redstone" and nine "Atlas" firings. Some of these may be sent into orbit, but the first full "Mercury"-"Atlas" manned launch into orbit is not

TABLE II(*a*)—*continued*

Name and description	Launching rocket	Launch date and estimated lifetime	Main purpose and results	Orbit			
				Perigee height (miles)	Apogee height (miles)	Period (minutes)	Inclination to equator (deg.)
"Courier 1A." Military active communication satellite. 500 lb, containing five high-speed tape recorders and radio equipment, capable of simultaneously receiving and re-transmitting teleprint messages at the rate of 68,000 words per minute, or recording for later transmission on receipt of a coded signal. Sphere of 51in diameter, powered by 19,152 solar cells plus nickel-cadmium batteries. (U.S. Army direction)	U.S.A.F. "Thor-Able-Star" as for "Transit 1B."	August 18 (failed)	Feasibility test of an active military communications system		First stage failed at launch		
"Sputnik 5." Experimental spacecraft. Satellite weighed 10,134 lb total. Instrument compartment 3250 lb, space cabin 5500 lb. Cabin contained two dogs, forty mice, two rats, plants, seeds, flies and other biological experiments, and a television camera for observing the dog's reactions. The dogs and twelve of the mice were in a special capsule inside the main cabin (U.S.S.R.)	No details issued, but probably about 1,000,000 lb thrust	August 19. Recovered August 20	As for "Sputnik 4," plus experiments on the effects of radiation and weightlessness on animal and plant life *Results:* Successful recovery achieved after eighteenth orbit, with dogs and mice alive. This was the first time television transmission had been made directly from a vehicle in space	190	211	90·72	64·57
"Pioneer 6" (see also later attempt of December 14, 1960). Lunar orbiting vehicle, 387 lb, carrying radiation instruments and magnetometers. A retrorocket was to supply deceleration force on approaching Moon. A 39in sphere with fifty four-bladed fans on surface for temperature control, and four paddles with 8800 solar cells in all. (N.A.S.A. direction)	U.S.A.F. "Atlas-Able" ("Atlas" ICBM with "Able" forming second and third stages)	September 25 (failed)	Investigation of cis-lunar space, especially radiation and magnetic fields	Failed to reach orbit owing to fault in "Able"—burned up on re-entry			
"Courier 1B." Military active communication satellite — as for "Courier 1A"	U.S.A.F. "Thor-Able-Star" as for "Transit 1B"	October 4. Up to 500 years in orbit expected; possible transmission life of one year	As for "Courier 1A." *Results:* Feasibility established; satellite working well — relayed 118 million words of teleprint during the first thirty-five hours of reception and transmission	586	768	106·9	28·3
"Samos 1" (Surveillance and Missile Observation Satellite). No details available, but believed to be about 4100 lb carrying infra-red sensing equipment. (U.S.A.F. direction)	U.S.A.F. "Atlas-Agena" B (similar to "Agena" A, as for "Midas 1"—but B has stop-start capability and improved thrust)	October 11 (failed)	Reconnaissance, especially detection of ballistic missile launchings	Failed to reach orbit owing to fault in "Agena" B			
"Explorer 8." Research satellite, 90 lb, fourth stage casing with instrument package, including radiation measuring instruments, telemetry, solar cells and batteries. 30in diameter, spin-stabilised. (N.A.S.A. direction)	U.S. Army "Juno 2" as for earlier "Explorer" attempt of March 23	November 3. Up to fifty years in orbit. Transmission ceased on December 27	Measurement of the concentration and speed of ionospheric particles *Results:* Aims achieved in principle, but transmission ceased much earlier than expected, presumably owing to battery failure	259	1419	112·6	50
"Tiros 2." Meteorological satellite as for "Tiros 1," but also carried seven infra-red sensors. (N.A.S.A. direction)	U.S.A.F. "Thor-Delta" as for "Echo 1"	November 23. 200–500 years estimated for orbit; transmission life about three months	As for "Tiros 1," plus measurements of Earth-reflected radiation in various spectral bands *Results:* Remarkably circular orbit achieved, and worked well initially, though orbit is higher than planned (380 miles). Recent faults (January, 1961) have severely limited photographing operations	415	435	98·1	48
"Transit 3A." Navigation satellite —as for "Transit 2A," but contained a more accurate electronic clock; also a double satellite. (U.S. Navy direction)	U.S.A.F. "Thor-Able-Star" as for "Transit 1B"	November 30 (failed)	As for "Transit 2A"	Failed to reach orbit—booster destroyed by ground command when a fault developed			
"Sputnik 6." Experimental spacecraft. As for "Sputnik 5," but total weight 10,221 lb. Dogs and other animals, plants, &c., were again carried. (U.S.S.R.)	No details issued, but probably about 1,000,000 lb thrust	December 1–2	As for "Sputnik 5" *Results:* Sent into too low an orbit. When the signal was given for descent, the vehicle re-entered along an unsuitable trajectory and burned up	112	155	88·6	64·58
"Scout 3." Payload of about 25 lb, including inflation equipment and a 14 lb inflatable sphere 12ft in diameter, composed of two layers each of aluminium and "Mylar" film to provide rigidity upon inflation. (N.A.S.A. direction)	"Scout." Four stages (all solid): (1) Modified from "Polaris." (2) Modified from "Sergeant." (3) and (4) developed from "Vanguard" upper stage	December 4 (failed)	Inflatable sphere was intended to measure air density and drag in its orbital area, planned for 410–1275 miles	Failed to reach orbit—second stage did not ignite and rocket fell into the Atlantic			
"Pioneer 6." As for earlier attempt of September 25. (N.A.S.A. direction)	U.S.A.F. "Atlas-Able" as for earlier attempt	December 14 (failed)	As for earlier attempts *N.B.*—This was fourth attempt (earlier ones: September 25 and November 26, 1959: September 25, 1960.) N.A.S.A. now have no further funds for this programme		Booster failed after launch		

* Still in fall.

likely to be made before the end of the summer (Fig. 26).

The flight plan for manned orbit involves deceleration from satellite speed by about 350 m.p.h. by retro-rocket towards the end of the third orbit, then descent and re-entry (Fig. 28). The retro-rockets may be fired by the astronaut himself, by ground command, or by an automatic timing device in the capsule. Minneapolis-Honeywell Company have developed an "Earth Path Indicator" to show the astronaut his impact point when injected from orbit. The display is a revolving globe with an indicator, and the device must be pre-set by the astronaut when he reaches orbit, using information received from ground stations. In the event of loss of contact with the ground during orbit, the astronaut will then be able to judge the appropriate time for re-entry with the aid of the instrument. Deceleration will commence west of California. During re-entry, the high-drag configuration will decelerate to about 600 m.p.h., being protected by a beryllium heat shield. At about 40,000ft, a small parachute will be deployed to stabilise the motion and reduce speed from a Mach number of 1 to about 185 m.p.h. At 10,000ft a larger cargo-type parachute will open and lower the capsule at about 30ft per second to a sea landing near the Bahamas to await final recovery. Large air and sea forces will observe and perform the recovery operation.

Among the changes made in the original design of the "Mercury" capsule are: the replacement of two small portholes with one large window, 21in by 11in, which will give the astronaut a wider angle of view; the addition of an emergency hatch opened by explosive bolts; and the incorporation of an air cushion between the heat shield and the capsule structure, to mitigate the effects of an accidental impact on land, to give added heat insulation and to serve as a sea anchor for normal recovery. There are now three ways for the astronaut to leave the capsule—via the top hatch, through a side door which opens mechanically, or through

TABLE II (*b*).—*Discoverer Series*

GENERAL AIMS

To test propulsion and performance (especially stability) in achieving near-polar orbits (the orbits achieved were between 100 and 160 miles).

To test recovery techniques for retrieving an instrumented capsule from orbit.

To collect research data with the instrument payload.

DESCRIPTION

Satellite consists of "Agena" rocket casing, including 300 lb instrument capsule. The capsule has a radio beacon, a rotating light, and radar "chaff" to aid recovery, and is ejected from "Agena" by a timing device for re-entry and recovery—usually on the seventeenth orbit. "Agena" is 19·2ft high and 5ft in diameter. Total weight in orbit about 1700 lb (U.S.A.F. direction)

CARRIER ROCKET

U.S.A.F. "Thor-Agena" A used for "Discoverers" 1–15. Launch weight 108,500 lb, 78ft high with 8ft diameter base; modified "Thor" IRBM first stage with "Agena" second stage.

U.S.A.F. "Thor-Agena" B used for "Discoverers" 16-20. "Agena" B has stop/start capability and improved thrust, and can be equipped with a special capsule to hold biological experiments or cameras and infra-red equipment.

"Discoverer" No.	Launch date in 1960 and lifetime where known	Results and remarks
9	February 4	Failed. A ground servicing tower caused damage to "Agena" before launch, and "Thor" shut down prematurely as a result.
10	February 19	Failed. Went off course at 20,000ft; destroyed by ground command.
11	April 15–26	Reached polar orbit. Capsule duly ejected but not detected after re-entry.
12	June 29	Failed to develop orbital speed; burned up on re-entry over South Pacific.
13	August 10. (Capsule recovered August 11)	First successful orbit and recovery of the series. Capsule retrieved from the sea.
14	August 18 (Capsule recovered August 19)	Instrument capsule recovered in mid-air by a Fairchild C-119 aircraft at 8000ft.
15	September 13	Capsule ejected but lost in a storm near Christmas Island in the Pacific.
16	October 26	Failed. First use of "Agena" B, which did not separate; both stages fell into the Pacific.
17*	November 14. (Capsule recovered November 16.) Satellite still in orbit at end December	Also carried solar radiation instruments in capsule. Sunspot activity occurred at this time, and ejection was delayed until the thirty-first orbit to obtain as much data as possible. Capsule again recovered in mid-air (9000ft). (This launch was under N.A.S.A. direction.)
18*	December 7. (Capsule recovered December 10.) Satellite still in orbit at end December	Usual "Discoverer" aims, plus biological experiments of radiation effects on human skin, bone marrow and blood cells, plant spores and algae. Capsule recovered after three days in orbit; caught by a C-119 aircraft at 14,000ft, near Hawaii.
19*	December 20. Transmission ceased December 25; satellite still in orbit at end December	No capsule—unlike usual "Discoverers." "Agena" B satellite carried instruments to measure the wavelength and intensity of infra-red radiation from the Earth. Transmission ceased unexpectedly early. Total weight in orbit: 2100 lb. Instruments are similar to those which may be used for future "Midas" and "Samos" vehicles.

* Still in fall.

TABLE II (*c*).—*Satellites still in orbit in December*, 1960

Those marked with an asterisk in Tables II (*a*) and II (*b*), plus the following, were still in orbit at the end of December:

Name	Launch date	Estimated life
"Explorer" 1	January 31, 1958	Four years
"Vanguard" 1	March 17, 1958	100 years—still transmitting
"Lunik" 1 (or "Mechta")	January 2, 1959	Indefinite—in solar orbit.
"Vanguard" 2	February 17, 1959	Ten years
"Pioneer" 4	March 3, 1959	Indefinite—in solar orbit.
"Explorer" 6 ("Paddle-wheel")	August 7, 1959	Now expected to orbit until about August, 1961
"Vanguard" 3	September 18, 1959	Seventy years
"Explorer" 7	October 13, 1959	Twenty years—still transmitting

Fig. 27—A "Mercury" capsule awaiting launching on a "Redstone" booster; the capsule, unmanned, experienced zero *g* for five minutes and re-entered at 11 *g*

the emergency side hatch using explosive bolts (Fig. 29).

"*Dyna-Soar*" *and Other Re-entry Vehicles.* — N.A.S.A. establishments are studying various kinds of re-entry vehicles, which form three broad groups: recoverable ballistic vehicles such as "Mercury," which have received longer development than any other type of re-entry vehicle and offer the most simple and quickest way of carrying out manned orbital flights; inflatable or collapsible winged structures; and metal gliders, of which "Dyna-Soar" is an example. Drag balloons are also being studied for deceleration and stabilisation prior to recovery, and the first "Ballute"—a 500 lb capsule equipped with drag balloon and parachute—was launched from Santa Rosa Island, Florida, on November 21, 1960, to a height of 32 miles. The capsule fell to 75,000ft, then inflated the 9ft diameter drag balloon, which brought its speed below Mach 1 by 35,000ft. The parachute was finally opened to lower the capsule into the sea, where it was recovered.

Inflatable configurations would be very large delta-winged vehicles with rounded leading edges. The immense wing area would give very light wing loading, decelerating at high altitudes where aerodynamic heating rates are comparatively small. For example, a two-man version would inflate to 133ft long by 76ft maximum span, with a loading of 1 lb per square foot. Collapsible structures consist of kite-like membrane wings, attached by cables: these would be deployed from the crew compartment before re-entry. The possible advantages of inflatable or collapsible structures are the stowage of the lifting surfaces during launch, thus removing the launch stability problems expected with rigid-winged vehicles, and high lift-drag ratios at very high altitude, with greatly reduced surface temperatures.

Various types of metal glider have been considered, but the favoured design is a delta-winged configuration, with heavy heat shielding on the lower surface—this vehicle would enter at a high angle of incidence, presenting a very blunt shape to the air, and the heat shield would protect the rest of the vehicle from the most severe re-entry heating.

Fig. 26—A "Mercury" capsule in course of checkout

The re-entry phase would be followed by a gliding phase at reduced incidence and an approach and landing at normal speeds. The " Dyna-Soar " manned boost glider concept, now being transformed into hardware by the Boeing Airplane Company under U.S. Air Force direction and with N.A.S.A. help, uses these principles (Fig. 30). The name is simply derived from the words " dynamic " and " soaring," signifying that the vehicle will employ both centrifugal force and aerodynamic lift.

The " Dyna-Soar " programme has been allocated 480 million dollars up to 1963, and this includes three vehicles for static tests and four each for unmanned and manned series of flight tests. The eight flight test vehicles will use a modified Martin " Titan " I.C.B.M. to boost them to sub-orbital

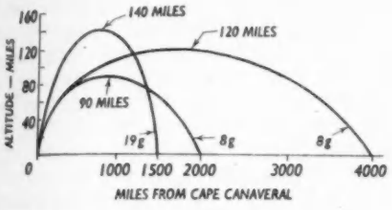


Fig. 28—" Mercury " trajectories afforded by " Atlas " booster

speeds. " Titan " is expected to withstand the heavy bending stresses caused by boosting a winged vehicle from the ground for, unlike the very thin, pressurised, stainless steel construction of " Atlas," the " Titan " has a monocoque structure using longitudinal planks of a specially strong aluminium alloy, and this structure will be further strengthened in modified versions for " Dyna-Soar." The B-70 aircraft has been proposed as a recoverable launcher for " Dyna-Soar " type vehicles, for this bomber should be capable of lifting a 10,000 lb glider together with a 40,000 lb liquid booster rocket to 70,000ft, releasing them at a speed of about 2000 m.p.h. for boost into a 300-mile orbit, and returning to base. " Dyna-Soar " is primarily a military vehicle, designed as a development version of a manned orbital bomber, and its adaptability for air-launch as well as launch from " Titan " bases could significantly increase its mobility as well as reduce expenditure on large boosters.

A full-size mock-up vehicle is expected to be ready early in 1961. The first flights including manned tests will be made in 1963 —these will be purely a test of the glide capabilities of a full-scale vehicle, released from a B-52 aircraft. Early in 1964 the first unmanned launch by " Titan " may be made,

Fig. 30—An impression of the separation of the "Dyna-Soar" glider from its " Titan " booster

and the first piloted flight is not expected until early in 1965.

The major problem is re-entry heating, for the configuration will not generate as much aerodynamic lift as would the previously mentioned very large, inflatable structures. Peak heating rates should approach 20kW per square foot to the main wing structure, and minimum surface temperatures will be around 1000 deg. Cent. Re-entry model tests with various high-temperature materials such as molybdenum, tungsten, tantalum and columbium are being carried out with a modified " Scout " rocket. Like X-15, " Dyna-Soar " must be capable of landing at an airfield. Unlike X-15, the craft will be travelling at orbital velocity at the time of re-entry (possibly after several complete orbits), and the conversion of this velocity to heat during re-entry will total some 13,500 B.Th.U. per lb, but a large percentage of this heat will be dissipated by heating the air, which is left behind in the wake. It is probable that the main surface will act as a radiation shield, i.e., radiating most of the heat input to space. Only a small percentage of the heat energy will be conducted into the vehicle. The worst affected regions—which will probably demand the use of ablating materials on top of high temperature metals—are the nose and the leading edges of the wings and vertical stabiliser fins ; these will also be blunted to minimise the heat input to the structure. A full review of " Dyna-Soar " from its early beginnings to date has recently been made by Mr. K. W. Gatland.[50]

Apart from possible military uses such as bombing, reconnaissance or orbital interception, advanced versions of " Dyna-Soar " could be used for rescue operations from manned vehicles in orbit, or as ferry vehicles between the ground and manned space stations.

" *Apollo*."—" Apollo " is a manned space vehicle weighing between 10 and 15 tons planned by N.A.S.A. to follow " Mercury." Three companies are at present making competitive studies for contracts : Martin Company, Convair and G.E.C.'s Missile and Space Vehicle Department ; and research and development contracts are expected to be awarded during 1961. " Apollo " will initially have a three-man crew, and will be used for orbital flights, circumlunar flights, and lunar orbits, each of which purpose needs a different vehicle. A modular concept is therefore proposed, consisting of three component structures for each purpose, the leading crew compartment section being the same in each vehicle.[51]

The industrial studies involve a review of the required systems, preparation of a programme, designation of the problems which will require the longest development time, and estimates of cost. Research and development are expected to commence in 1961 and continue until the late 1960's. Earth orbital and circumlunar flights are planned for about 1968 onwards, using " Saturn."

Radiation will be a serious problem in circumlunar travel, for three types of radiation will be encountered : Van Allen, cosmic and solar flare. At present, shielding seems feasible only in the case of Van Allen radiation. Further data from space probes is required to help in assessment of the seriousness of radiation and other hazards such as micrometeorites. The progress of the " Mercury " programme may well affect plans for " Apollo," in particular by providing data on the effects of weightlessness : if these are severe, some form of artificial gravity could be considered for " Apollo."

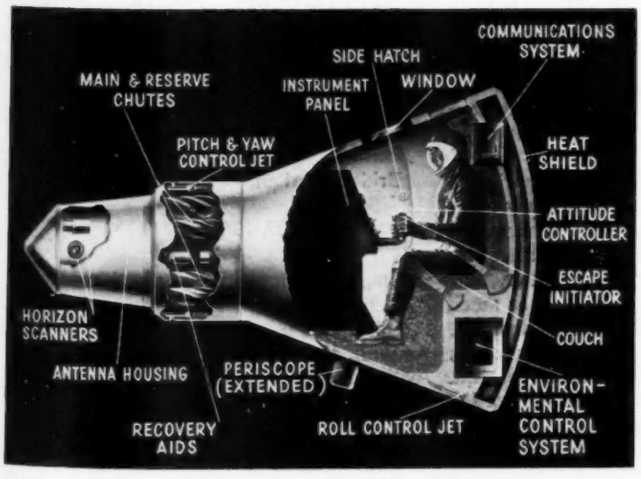


Fig. 29—Diagram of " Mercury " capsule

CONCLUSIONS

During 1960 solid rockets continued to make considerable progress. The American programme showed great diversification of scientific and application satellites using pre-1960 boosters. Great efforts continued to be made for the " Mercury " project and the next generation boosters got under way. Russian efforts were almost exclusively concentrated in developing the large booster and proving the 4½-ton recoverable orbital vehicle. This led to the first successful manned orbital flight on April 12, 1961, by Major Yury Gagarin.

REFERENCES

[50] " Background to ' Dyna-Soar,' " K. W. Gatland, *Aeroplane and Astronautics*, January 6, 1961, pages 19–22.

[51] " ' Mercury '—and after," Kenneth Owen, *Flight*, December 2, 1960 pages 867–69.

LETTERS AND LITERATURE

Letters to the Editor

AESTHETICS IN ENGINEERING DESIGN

SIR,—I notice in the issue of THE ENGINEER dated March 10, 1961, an article by Mr. Litherland under the above title and I understand that this is effectively the paper which he read at the Autumn Conference at Buxton held by this Section last October. In view of the excellent notice which you gave us in your issue of October 21, 1960, I am a little disappointed that no reference to the Conference is made in connection with this paper.

G. R. K. MARTIN,
Hon. Secretary.
Institution of Mechanical Engineers,
North-Western Branch,
Graduates' Section.
March 28, 1961.

[Our apologies are due. In all but minor respects and through the omission of illustrations the article was effectively the paper Mr. Litherland presented at the Conference. We are pleased that our oversight has been brought to our attention so that we can make amends.—ED. THE E.]

CANADIAN PACIFIC TRANSCONTINENTAL TRAINS

SIR,—In No. III of "Canadian Pacific Transcontinental Trains" (March 3), three slight errors have intruded, for which I apologise.

(1) Fig. 14, Spences Bridge, between North Bend and Kamloops, is not a Divisional point—the other stations are.

(2) According to the map, the railway appears to thread three ranges *en route* to Alberta; I have never noticed more than two! Actually the Connaught Tunnel pierces the top of the Selkirk Range, and Beavermouth is at the foot of the eastern slope; from there the line follows the Columbia River valley to Golden, where the Rocky Mountain Range begins, and the Kicking Horse River. The draughtsman seems to have become a little confused, which it is easy to do; there is a sea of mountains hereabouts.

(3) The first line of the second paragraph, page 328, should read: "At Field time changes, being put *on* an hour"—not back. Going east we are running to welcome the sun, greeting it three times *en route* to Montreal.

Locomotive experiences in several countries have brought me into contact with all sorts and conditions of enginemen. Many are as ships that pass in the night, but some—for a variety of reasons outstanding—I keep in touch with, and one of the latter, first met when a fireman in the cab of the "Elizabethan," has since transferred from King's Cross to another depot, and is now a driver. He writes:

"I have read and enjoyed the articles 'Canadian Pacific Transcontinental Trains' in THE ENGINEER . . . you have gone into great detail comparing the fireman in Canada and his counterpart in this country, and it would appear that the ones on your side of the Atlantic get the best part of the deal, b t what is to be done about it? If you give my fireman a rise you would have to give myself and countless thousands of other railway workers a corresponding increase, which would mean fares going up and traffic going down. . . . You said in the last article that the hardest day's work for a fireman is Leeds to London and back in a day, a total of 372 miles, but I am afraid you were wrong—King's Cross to York and back holds the record, 188 each way, 376 miles." (To be strictly accurate, what I said was "the toughest I have come across in England."—E.H.L.)

"How would one of the Canadian firemen have fared on the first week I had in the top link at King's Cross in 1953?"

		Miles
Sunday,	London–Newcastle	268
Monday,	London–Newcastle return ...	268
Tuesday,	London–Doncaster return ...	312
Wednesday,	London–York return	376
Thursday,	London–Grantham return ...	211
Friday,	London–York return	376
Saturday,	London–York return	376
Sunday,	London–Newcastle	268
	Eight days, total mileage... ...	2,455
	Average miles per day	307
	Average miles per week	2,149
	Coal fired, at 45 lb per mile ...	50 tons

The mileages, averages, &c., in the table are mine—they were not in Driver M——'s letter.

Compare the above with the Canadian fireman's stint: three-unit diesel engine in passenger service: 4800 miles per month (Union limit); 1200 miles per week (four or five days); 240 miles per day.

For which back-breaking performance he receives £50 per week. I called this "feather-bedding" in my article, and underline it here. In my opinion the Canadian fireman is very much overpaid, and his British opposite number the reverse, but as my friend Driver M—— of —— depot sagely remarks, "What is to be done about it?" I am sure I do not know!

He goes on: "The Thursday *short* run (my italics) to Grantham and back was followed on Sunday by Newcastle again. This week's work was the hardest I ever did, and with a different driver nearly every day it gave me a good breaking-in for the years ahead." . . . The letter goes on with a very graphic and pertinent description of difficulties that can arise due to undersize shovel-plate and firedoor, a pet subject of mine which I hope to enlarge upon on a future occasion, so I will not quote his remarks here.

I think it will be admitted that my friend's figures give point to my comparison of British and Canadian firemen's respective duties and remuneration. The former has my sympathetic interest—the latter. . . . Concluding, the figures really come as much of a surprise to me as they will, I imagine, to many people—I should never have thought such a big weekly mileage could be reached.

EDWARD H. LIVESAY

Victoria, B.C.,
March 25, 1961.

MILLIONS TO BE SAVED?

SIR,—Through the hospitality of your columns we have been able to weigh the relative merits and demerits of converting our railways into roads. By now it must appear to an unbiassed reader that only the most sanguine exponent would proceed with the scheme.

May I propose that it is now time to consider turning our roads partly into railways by the reintroduction of electric tramway systems? The efficiency of a transport artery so judged by the number of persons conveyed safely along it in a given time, and by use of tramways the number of persons, as distinct from vehicles, able to pass along the average suburban main road should be significantly increased.

ROY H. THORNTON

Barking, Essex.
April 6, 1961.

SIR,—I refer to the railways conversion correspondence in which each side has put forward what they sincerely believe to be convincing arguments.

May I suggest that the wisest plan would appear to be the building of roads above railways thus giving the best of both worlds.

It is possible that the following advantages would accrue:

1. Brigadier Lloyd would get even better roads because they could be cantilevered out to give adequate width and, in the limit, one road track could be above the other through towns.

2. The existing railways belong to the nation and are wonderfully engineered thus minimising land purchase and civil engineering costs of overhead roads.

3. Minimum disturbance to the existing railway system would be involved although to avoid damage by steam blast the building of overhead roads should follow the diesel and electric modernisation.

The only disadvantage would appear to be the cost but since the Railway Conversion League are entirely correct in their insistance upon the urgent need for the new roads and the railway protagonists are also equally correct in insisting upon our need for the railways to continue, it would appear that the expenditure to provide roads above railways could be entirely justified.

A similar suggestion was made by Lt.-Col. Lovell (Discussion, Brig. Lloyd's paper, *Proc. I.C.E.*, Vol. 4, November, 1955, No. 6).

H. H. ANDERSON

Bridge of Allan,
Scotland,
March 28, 1961.

SIR,—I am not surprised that Mr. Harding wants to retire from the fray as he seems quite unable to tell us how we are going to provide the vast multi-storey parking lots without using the sites of the railway stations and goods yards.

The best he can do when it comes to urban motorways is to mention the proposed

extension of M1 to the south, but even if this is built there will still be eight miles of congestion to Marble Arch.

How any one can describe the A.45 between the M.1 and the outskirts of Birmingham as a first-class dual carriageway I cannot imagine. I should say that it is a very third-rate affair which is riddled with roundabouts and many other hazards.

I therefore think that the conversion of the London Midland main line is a perfectly logical development which would be very much cheaper than electrification as well as being far more useful.

Although a large proportion of this correspondence has been taken up in discussing urban transport problems with particular reference to the London commuters, I do not think we should lose sight of the many other advantages of railway conversion.

The most important of these is that industry and population will be able to decentralise on an unprecedented scale.

This will do a great deal to relieve the pressure on the heavily over-populated Greater London area and it will encourage the building of new factories where coal-mining is declining as well as in rural areas.

In conclusion I would suggest that railway conversion will make it possible for people to live much closer to their work than at present and thanks to the very cheap road transport the trend will be for the materials to do the travelling between factories while the people reduce commuting to a minimum.

A. I. WATKINSON

Harrogate,
March 29, 1961.

Book Reviews

David Brown's. By DESMOND DONELLY. William Collins, Sons and Co., Ltd., 14, St. James's Place, London, S.W.1. Price 21s.

THE sub-title of this book, "The Story of a Family Business," is well chosen, for the Huddersfield firm of gear makers known the world over as "David Brown's" is still, 100 years after the first David Brown set up his little pattern-making business, very much of a family concern. The present chairman of the company, Mr. David Brown, is a grandson of David Brown the founder, and the chairman's son—again David—occupies a senior executive position in the business.

David Brown the first was only seventeen years old when, in 1860, he started to make patterns in rented premises which were part of a stable. This first order was for gear patterns for his landlord's foundry, and thus began a connection with gears which has been the major concern of the firm ever since, though it is now far from the only one. Under two generations of Browns the firm developed from an employer of two men to a maker of gears of every kind and an employer of more than 1000 workers. Under the present chairman the business has expanded again to take in various other types of manufacture, such as tractors, machine tools and high-performance motor-cars, and now has fourteen factories and nearly 10,000 employees.

It is not uncommon, in Great Britain, for a company to reach its centenary. Nor is it unusual for a large business to be built up from very modest beginnings in the lifetime of the founder. But it is rare that one man succeeds to a fortune and a comfortably successful business and then builds it up to great size and importance in the way the present chairman has done. It follows that the sorty told in the book is to a great extent the personal story of the present Mr. David Brown. But that is not all. The present chairman had a father who believed that a business could best be learnt the hard way, and the son had to work for his living, finding out how the firm worked from the bottom up. The story is therefore one of personal endeavour and effort, not only of the present chairman, but of his predecessors, and, when the business grew too large for one man to control in detail, of the work of those who were brought into the team of management. It is a story of a firm which has grown with gear technology, and has taken no small part in its development. When the first David Brown was in control one of the jobs he had to do was the cogging of mortise wheels—the fitting of hornbeam or applewood teeth into the mortises of cast iron wheel rims—now virtually a forgotten art. He took it in his stride, as his successors were to deal with such problems as the cutting of involute teeth and the production of the complicated gear assemblies demanded by the aircraft and motor industries.

There is little real technical information in this book, and anyone who seeks a detailed history of gear manufacture will be disappointed. On the other hand, it is a very readable account of the human side of an important business, of the development of men's ideas, and of the constant struggle to keep abreast—or ahead—of the times. It is a story, too, of success, sometimes against considerable odds, and occasionally in spite of dismal prophesies.

Uddeholmaren. Published by Uddeholms Aktiebolag, Sweden. English edition obtainable from Uddeholm, Ltd., Crown Works, Northwood Street, Birmingham, 3.

As one of the largest enterprises in Sweden, the Uddeholm Company is principally concerned with iron, timber, and water power, which are the basic material resources of western Sweden. Uddeholm has started the publication of an English edition of its journal *Uddeholmaren*. The first issue contains articles on steelmaking research, the new Hagfors rolling mill, all-the-year-round forest work, fishery conservancy, the Company's activities in 1959, and others. Copies may be obtained on request to the company's Birmingham office, at the address given above.

Reinforced Concrete Piling and Piled Structures. By F. E. WENTWORTH-SHIELDS, W. S. GRAY and H. W. EVANS. Concrete Publications, Ltd., 14, Dartmouth Street, Westminster, London, S.W.1. Price 18s.

THIS is the second edition of the book originally written by the first two authors. Since it was first written in 1938 various codes of practice have been published dealing with site investigations, foundations and reinforced concrete. The opportunity has been taken in rewriting it for this edition to incorporate the relevant information in these codes. The book deals essentially with precast piling and it does this thoroughly for design, fabrication and driving. In addition soil investigations and the design of pile caps are more briefly dealt with, while piled structures such as walls and jetties are considered in some detail.

The subject of bored piles is dealt with simply by describing the various piling systems now in vogue, but this only takes six pages out of 140 and is perhaps the most disappointing part as it virtually cuts out the subject of piled foundations for buildings; because of site restrictions these are usually of the bored type. The modern developments of large diameter bored piles are only mentioned and no mention is made of bored piled curtain walling or of short bored piling used as an alternative for deep strip footings. Prestressed concrete piling has been excluded in this book. It is perhaps a pity since some notable lengths have been pitched and driven and have proved economic when the pile size has been determined by bending stresses which arise during pitching or subsequently in service. Nevertheless the book covers excellently the field chosen, i.e. precast reinforced concrete piles and their use in civil engineering piled structures.

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Plasticity. Edited by E. H. Lee and P. S. Symonds. The Pergamon Press, Ltd., Headington Hill Hall, Oxford. Price 70s.

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A Compendium of Spherical Astronomy. By Simon Newcomb. Dover Publications, Inc., 180 Varick Street, New York, 14, New York. Price 2.25 dollars.

Dynamics of a System of Rigid Bodies. By Edward John Routh. Dover Publications, Inc., 180, Varick Street, New York 14, New York. Price 2.35 dollars.

Highway and Airport Engineering. By Adrian R. Legault. Prentice-Hall International Inc., Publishers, 28, Welbeck Street, London, W.1. Price 79s.

Fast Reactor Cross Sections. Vol. 4. By S. Yiftah, D. Okrent and P. A. Moldauer. The Pergamon Press, Ltd., Headington Hill Hall, Oxford. Price 35s.

World Railways, 1960. Sixth edition. Edited by Henry Sampson. Sampson Low, Marston and Co., Ltd., Potter Row, Great Missenden, Bucks. Price 105s.

Linear Circuits. Part 1. *Time-Domain Analysis*. By R. E. Scott. Addison-Wesley Publishing Company, Inc., 10-15, Chitty Street, London, W.1. Price 38s.

Kinematics of Nuclear Reactions. By A. M. Baldin, V.I. Gol'danskii, and I. L. Rozenthal. The Pergamon Press, Ltd., Headington Hill Hall, Oxford. Price 42s.

The Complete Scientist. The Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price, Cloth Edition 18s. Paper Edition 12s. 6d.

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Hyperstatic Structures. Vol. 11. By J. A. L. Matheson and A. J. Francis. Butterworths Scientific Publications, 4 and 5, Bell Yard, London, W.C.2. Price 60s.

Introduction to Electrical Engineering. Third Edition. By Robert P. Ward. Prentice-Hall, International Inc., Publishers, 28, Welbeck Street, London, W.1. Price 77s.

The Engineer in Commonwealth Development

By H.R.H. THE DUKE OF EDINBURGH

We here reprint in part the Seventh Graham Clark Lecture delivered on Thursday, April 13, in the Great Hall of the Institution of Civil Engineers. The whole of the proceedings was relayed by closed circuit television to overflow meetings in the lecture theatres of that Institution and those of the Institutions of Mechanical and Electrical Engineers, so that there was a total audience of some 2200 members. The lecture surveyed the resources of the Commonwealth in relation to the work of engineers and referred also to research and education. It stressed particularly the need for engineers to acquire a broad general education so as to be able to appreciate the magnitude of the problems of Commonwealth development not only technologically but also in a more human sense.

I AM going to take it for granted that it is generally accepted that development in the broadest sense is a good thing. I hope I can assume that mankind is better off with proper food, sanitation, housing and all the material comforts which modern science, engineering and industry can provide. I am not assuming, however, that this material development necessarily implies a higher standard of human civilisation. This, I believe, depends upon qualities of the mind and spirit which are not directly related to material comfort and convenience.

Given the need for development in the material sense it does not take a great stretch of the imagination to visualise the engineer's part in the process. There are, in particular, four ways in which the engineer can implement and influence development :

1. By continually finding practical ways and means of applying scientific principles and discoveries in power, industry, transportation, communication and construction. This means that research establishments are needed in all the divisions of engineering so that practising engineers can apply the benefits of fundamental scientific research.

2. By the application of the latest and most efficient methods to individual projects. This means that practising engineers must have some way of keeping up to date.

3. By the careful administration, maintenance and improvement of the engineering complex. Building or developing some project from scratch may have a great many difficulties but maintaining and improving a project which has been in existence for many years calls for even more skill and administrative ability. Railways are an obvious example.

4. By the technical training and education of the next generation of engineers. This is very much the engineer's responsibility and whatever the rewards of practice may be, nothing is more worthwhile in the long run than teaching the next generation.

The engineer is in fact the means by which the people are able to enjoy the fruits of science, whether in building new projects, or in maintaining, keeping up to date what is already in existence. I need hardly list the highly developed communities of history which decayed for the lack of engineers to keep their great works in operation.

Simple technical know-how is also not enough. In order to make a really worthwhile contribution the engineer needs the vision to appreciate what is possible as well as the technique to realise his dream. It is also wrong to assume that the engineer is simply concerned with material gadgetry of the purely practical and commercial side of life. All large-scale projects and modernisation plans are bound to have a profound and lasting influence upon the lives of very great numbers of people. Unless their conception, execution and running are all based upon a practical humanity they will contribute very little to man's progress.

That is why technological training must be combined with a broad general education. Each generation must learn that technical knowledge without a sense of mission and responsibility is wasted. Education which merely produces a sense of dissatisfaction and frustration and a kind of topsy-turvy snobbery about what is suitable and unsuitable employment is a failure. The system must instill a sense of the value of engineering to human development so that people come to look upon it with the same sense of service as missionaries and doctors.

Food and Agriculture

The engineer has two kinds of resources with which to work. There are the renewable resources : by which I mean those which grow or which are renewed by the climate, and non-renewable resources, those which are extracted once and for all.

Luckily in supplying humanity's basic need of adequate food the resources are not only renewable but the area which can grow them, as well as the quantity from a given area, can be substantially increased by modern engineering and scientific methods. This is particularly fortunate because no country can hope to reap the benefits of industrialisation without a sufficient and cheap supply of food for both the rural and urban population. Secondly if the world's food resources had a known limit at this time the tremendous increase in the population of the world would pose an insoluble problem.

I promised not to bring in too many statistics but there are one or two which I am sure you will find revealing. The Commonwealth fraction of the world land area is 23 per cent and the fraction of the world population is 24 per cent. Even though Britain has the highest population density, 68 per cent of the Commonwealth population is in India and Pakistan. Out of a total Commonwealth population of 682 million no less than 56 per cent are employed in agriculture—5 per cent of Britain's, 12 per cent of Australia's and 71 per cent of India's. The really interesting part of that comparison is that agriculture, forestry and fishing employ 5 per cent and are worth 4 per cent of the gross domestic product in Britain. Australia employs 12 per cent which produces 17 per cent, whereas in India 71 per cent of the population only produce 47 per cent of the gross domestic product. This shows very clearly that great strides are possible in agricultural productivity.

I said just now that for the time being we are also fortunate that the land area for agriculture can be increased. In fact 44 per cent of the Commonwealth land area is either unused, built on or wasteland. This figure needs to be qualified, however, because one-fifth of the undeveloped land surface is too cold, one-fifth too arid, one-fifth is mountains and one-tenth has no soil. This leaves about 30 per cent as potentially cultivable and gives some idea of the scope for bringing deserts, equatorial forests and tropical grasslands into production, and the tremendous contribution which engineering can make to agriculture.

Four things are needed to stimulate and increase agricultural productivity :

1. Extend the area under cultivation which generally means the provision of water in dry areas the removal of water in swampy areas, and the control of pests, diseases and weeds.

2. Increase the productivity of the soil by applying more nutrients. This is the first impact of industry proper upon agriculture because plants need fixed nitrogen, phosphorus and potassium which have to go through some sort of industrial process before they are usable.

3. Better equipment for use on the land so that together with the increased use of fertilisers the output per acre can be substantially improved. In the industrially developed countries very sophisticated machinery is needed to increase the output per man. In the less developed countries the emphasis should be on improved design of simple instruments. Remember the groundnut scheme which prompted the remark "Give use the job and we will finish the tools."

4. A system of agricultural organisation which will make it worthwhile for the rural population to grow food for sale. This includes the organisation of land tenure, proper transport and marketing facilities and a comprehensive advisory service.

It is no use attempting any or all of these things without taking human nature into account. These points may be self-evident to an outsider but you cannot, without much suffering, force human nature to accept overnight a complete change—even for the better—of the basis of its existence. The art in this case is to reconcile the interests of the individual with the interests of the State.

Even without mechanisation or increasing the area under cultivation productivity can be very greatly improved by the application of fertiliser and trace elements where necessary. This operation, however, depends upon the cheap and therefore industrial production of fertiliser which in turn depends upon cheap power. For this purpose the natural gas fields of Pakistan are most convenient as they supply both the power and the raw material for fertiliser production.

Taking all this into account it is rather sobering to find that the Commonwealth share of the world's food production is not very impressive. Of the basic foods only rice, 24 per cent, barley, 20 per cent, and mutton 23 per cent, are in proportion to our population. All the others are way below 20 per cent of the world's output. Coarse grains are only 9 per cent, pigment is 5 per cent and wheat 14 per cent. This is in spite of the fact that many areas in Commonwealth countries regularly produce two and

sometimes three crops per year already.

From what I have said I need hardly emphasise what is expected of engineers for agriculture especially in the less developed countries.

The next stage after food production is food preservation. There are one or two old-established methods of preserving food, but generally speaking the whole technique of food preservation is due to modern engineering methods. It has even gained the title of food technology and not even the homely and old-fashioned smoking and curing methods have managed to escape the food engineers.

Energy

There is a close relationship between the amount of energy available per head of the population and the state of material development of a country. The explanation is obvious. Power for irrigation pumps and fertiliser factories raises agricultural productivity. Power for transport distributes agricultural products, brings raw materials to industry, distributes industrial products and transforms individual mobility. Power for industry makes it possible to harvest or extract the raw materials with greater efficiency and it is the very life blood of industrial processing and manufacture.

The production of energy by the Commonwealth is only 12 per cent of the world's production even though India and probably several others have doubled their output in the last five years. This figure of 12 per cent has to be reduced to 10 per cent if you leave out the oil produced in Bahrein, Kuwait and Qatar and it means that Commonwealth countries at present only produce 3·5 per cent of the world's oil and 3 per cent of the natural gas.

There is a very real urgency to increase the energy production and distribution in the Commonwealth. In this field the engineer has almost unlimited scope and the solution of this energy problem demands more than skill and intelligence, it demands the services of far-sighted engineering administrators to exploit every indigenous source of energy and to plan the most economic form of energy production from other sources.

Australia for instance is very short of water for all purposes. The Snowy River Scheme will do much to meet immediate demands for energy and irrigation, but there are virtually no other sources of hydro-electric energy on the continent. Fortunately she has considerable resources for the production of nuclear energy.

New Zealand on the other hand has fairly large reserves of water power, but they happen to be on the South Island whereas the majority of the population is on the North Island. I see that the New Zealand Government are about to call for tenders to lay power cables across the Cook Strait. This immense engineering project is expected to cost about £19,000,000.

Engineers have also made it possible to harness the geothermal steam in the North Island to energy production which was otherwise merely a pleasant tourist attraction.

India has great reserves of coal, but they happen to be mostly on one side of the subcontinent while power is badly needed in many distant places which have no alternative sources. Unfortunately the cost of transporting the coal or the electrical energy is prohibitive so that there may be openings here for nuclear power stations.

In Canada the situation is that 85 per cent of her electricity is provided by hydro-electric stations and she has still only tapped 28 per cent of her resources of water power. I flew over the Hamilton Falls in Labrador not long ago and I am not surprised that the engineers have cast covetous eyes on so much energy going to waste.

Power is related to industrial productivity, but cheap power can also attract industry. In Ghana I saw the site for the Volta River dam which will make it possible to exploit the bauxite deposits not far away for conversion into aluminium.

The giant Kariba dam on the Zambesi will give a tremendous stimulus to primary and secondary industry throughout the Federation of Rhodesia and Nyasaland.

Like Australia, South Africa is also short of water for all purposes, but on the other hand she has vast reserves of easily mined coal. As a result she is to build a plant for the conversion of coal into oil which is expected to meet one-seventh of the Union's present needs.

I have only referred to the large members of the Commonwealth. It is worth remembering that the smaller places have even more urgent problems without the material or economic resources with which to solve them. The Atlantic and Pacific islands need energy badly, but unless they can harness the wind, the sun, or the tides, there is little scope for development.

Industry and Resources

It is becoming increasingly popular to look upon industry merely as a convenient way of giving employment. Industry does undoubtedly give employment, but that is not its basic function. Industry exists for three reasons :

1. It produces those things which are needed by a community to live a reasonably comfortable existence.

2. It also produces those things which though not essential to human existence are very nice to have.

3. It produces things which can be sold to other countries, preferably at an overall profit.

It is difficult and probably misleading to try and generalise about the overall position of industry in the Commonwealth. In the renewable raw material—other than food—production varies from 84 per cent of the world's jute to 51 per cent of wool to 11 per cent of cotton and 10 per cent of timber. In mining the Commonwealth produces only 11 per cent of the world's iron ore, but more than its share of many other metallic ores. I have no figures for the manufacturing industries as a whole, but it is significant that the Commonwealth produces only 11 per cent of the world's steel, 15 per cent of the aluminium and 11 per cent of man-made fibres. If you take this in conjunction with the fact that in only five major Commonwealth countries do the manufacturing industries account for more than 20 per cent of the gross domestic product while at least in six countries agriculture and forestry account for more than 40 per cent of the gross domestic product, as well as the fact that we only produce 12 per cent of the world's energy, the picture comes into rather sharper focus.

The implication is that in agriculture, basic industries and energy the Commonwealth output is not in proportion to its area or population.

Transport and Communications

Having outlined the contribution which engineers can make to the development of agriculture, energy and industry in the Commonwealth, I must quickly add that none of their efforts would bear any fruit without an adequate system of transport and communications. It is virtually impossible to develop natural resources, or improve and augment the food situation, or even to enjoy the benefits of industrial enterprise without a comprehensive network of public and commercial transport and communications. Indeed transport and communications are the means whereby the whole process of development is given purpose and direction and the only way by which the people can begin to adapt themselves to changing circumstances. A community which is without the proper means of movement and contact is cut off from the world and therefore can only exist upon its own—usually very limited—resources. It cannot co-operate with its neighbours and its intellectual level is also bound to be restricted.

A measure of the importance we attach to transport and communications in Britain is the amount of time and space devoted to its discussion. Anyone can start an argument any time by just mentioning British Railways or British roads.

I sometimes wonder whether our transport engineers are fully aware of the enormous difference in scale between the problems of transport and communications in these islands compared to the larger Commonwealth countries.

There are similar difficulties in air transport. The distances, geography and climate in Britain are so different from other Commonwealth countries that it is not altogether surprising that there is an entirely different attitude to flying.

The British aircraft industry is the most highly developed in the Commonwealth for the time being, but it cannot hope to continue to play a major part in the development of the Commonwealth unless it has the services of imaginative engineers who understand the needs and the conditions of the other Commonwealth countries.

In sea transport conditions are of course much the same all over the world. From the engineer's point of view therefore the two most fruitful fields of activity are in the process of shipbuilding and in the facilities for cargo-handling both in ships and ashore. Although it looks as if economics are against nuclear-powered merchant ships for the time being, it would be wrong to neglect their possibilities. It seems a pity that the D.S.I.R. Report on the shipbuilding industry in Britain should have caused so much trouble. A little mild and well intentioned criticism, even if its accuracy is disputed, should be treated as a signpost rather than as a slander. I admit it may be easier for me to take this attitude as I have to bear criticism rather more frequently than most.

Scientific Research

Many of the great strides in engineering history were made before scientific research was used deliberately to find new techniques. In recent times, however, we have come to think of science as producing the new ideas and engineering as the means of exploiting them. So much so that we are inclined to forget that much scientific research is only possible with the aid of very advanced engineering. Computers, electron microscopes, accelerators, radio telescopes and satellites are no longer bits of apparatus that can be knocked up in the lab. All these instruments and many others are the products of a highly sophisticated engineering industry.

As the developing countries begin to establish their own basic and applied research organisations and their own centres of

advanced teaching, these complicated instruments will be in great demand and it is reasonable to suppose that they will get more rather than less complicated in the future.

Education and Training

If it is easy to start an argument about transport, it is just as easy to start a riot about education and training. But on this occasion I do not want to start an argument or a riot, I only want to draw your attention to some of the problems and difficulties facing engineering training and education in the Commonwealth. One of the problems of engineering education is that it covers such a wide field. It includes science to manual skill and everything in between. It can be sub-divided into a number of specialisations and yet none of them are any use by themselves and all must have a proper appreciation of the part which engineering as a whole plays in the organisation of modern life and in future development.

To get an accurate picture of the position in Britain I recommend a comparison with our industrial competitors in Europe. For instance UNESCO estimates that the number of University students per million of the population in Britain is the lowest in Europe. No other country expects its students to graduate in three years. Even plans for the future are not very encouraging. Sir Geoffrey Crowther has estimated that by the early 'seventies only about 4 per cent (6 per cent men, 2 per cent women) of the children who are now just beginning their education will be able to carry it as far as a first or bachelor's degree. If the birth-rate continues to go up this proportion will of course go down unless more places are provided. He goes on to say : " Looking forward as best we can to the society of the twenty-first century, to its economy and above all to its technology, can we conceive that it will be adequately run by a generation of whom only 1 in 25 will have reached even a first degree. Is not this, in fact, a formula for national decline ? " In all fairness I must add that Sir Geoffrey Crowther has not taken into account other forms of higher education such as Teacher Training, Colleges of Advanced Technology and Technical Colleges, nor all the students who will soon be taking the Dip. Tech., many of whom will be engineers.

Dr. Bowden, of the Manchester College of Technology, recently drew attention to another aspect of this problem. " A recent statistical survey," he wrote, " has shown that the British economy is expanding more slowly than that of most other European countries. On the assumption that the gross national product per head was 100 in 1950. West Germany has now reached 171, the O.E.E.C. countries average 139 and the United Kingdom only 122 ; and this despite the fact that the proportional rate of investment per worker in this country has been quite high during the last decade. It is clear that our investment has not been as productive as it should have been ; I believe this may well be due to the inadequacies of our educational system."

After that rather gloomy piece I must quickly add that in January of this year the Government produced a White Paper on " Better Opportunities in Technical Education " which sets out the proposed reconstruction of the system of courses for technicians, craftsmen and operatives in the technical colleges of England and Wales. These have still to be implemented, but there seems to be every reason to hope that they will have a profound effect upon the whole pattern of technical education. At least they recognize that no new idea from a scientist or designer can become an efficient piece of equipment without the particular skill and ingenuity of technicians, craftsmen and operatives.

It only remains now for these plans to be matched in that unhappily large section of industry which still does not provide sufficient effective training for its young recruits.

It was with this situation in mind that the City and Guilds of London Institute agreed, at my suggestion, to run a Commonwealth Technical Training Week at the end of May and the beginning of June this year. There has been a most encouraging response from all Commonwealth countries and we hope very much that the Week's activities will attract the attention of young people, their parents and employers to the need for technically trained people and to the ways and means of getting that training.

This problem of higher education and technical training cannot be solved once and for all. Every country in the Commonwealth should look forward to progressive development which means that plans for education must look ahead to the needs of the next generation.

It is quite useless for the more fortunate countries to offer their help in building dams, power stations and factories if the managers and engineers needed to operate them are not available. Furthermore it does not take very long to put up the physical structures, but it may take anything up to fifteen years for the people to gain sufficient knowledge and experience to run them.

If the various aid programmes, such as the Colombo Plan, are to have any lasting value, there must be a strong emphasis on technical education. Colleges, equipment and teachers are all badly needed and teachers in particular will be needed for a great many years to come. This means that those countries with well-established higher technical educational facilities must take this added responsibility into consideration. Providing places for other Commonwealth citizens is only a temporary emergency solution, in the long run engineers and technicians must have their basic training in their own countries. Dominating this whole worrying problem is the constant increase in population.

The significance of all this to engineers is that you cannot expect development and progress to be maintained unless you make sure that there are enough people in the next generation capable of carrying on your work. Only engineers themselves are capable of estimating what a nation's future needs are likely to be in graduates and technicians. Only engineers can decide what the qualifications should be in the light of the current state of engineering development. Only engineers who have themselves been properly educated can begin to impart the necessary knowledge into the next generation. It is not simply a matter of maintaining standards of knowledge and conduct, it means that you are ultimately responsible for the material well-being of your fellow citizens.

Conclusion

In this lecture I have tried to show that the engineer is the key figure in the material progress of the world. This is particularly important at this moment in history when we are beginning to realise the dangers in a situation where some countries are enjoying all the fruits of material progress and others none at all. There is a growing feeling that this unbalance is neither morally acceptable nor is it likely to improve the chances of peaceful conditions. It is obviously impossible for the more fortunate countries to stop and simply wait for the others to catch up, and it is equally impossible for the others to catch up unaided. The gap in material standards can only be reduced by a real co-operative effort and since material development depends so much upon engineers, that co-operative effort means a co-operative effort by engineers.

The first necessity is an effective administrative framework so that the co-operation and collaboration between engineers of the world can take place. Take, for instance, engineering and technical training. There is said to be a shortage of engineers in the developed countries, there is no doubt about the shortage in the less developed countries. There is also a shortage of engineering teachers, and they are even more important because teaching does not only depend upon the number of teachers, it depends very much upon the moral and cultural example which they set. We cannot expect the direction or the momentum of development to be maintained without an adequate number of suitable engineers and technicians and the means of educating and training them.

I keep harping on the need for engineers to be educated as well as trained because I do not believe that specialist training necessarily affects those characteristics of the mind which are needed for human administration. The qualities of imagination, enthusiasm and compassion are present to a greater or lesser extent in all of us, but it needs the process of a general and liberal education to give them point and direction. Specialist training can give people the ability to make sweeping technological innovations, but it needs a broad and liberal education to enable people to foresee the effects of those innovations and to recognize how to introduce the fruits of modern science and engineering to the best advantage of the people.

That is the main task for the engineer in the future and the engineers of the Commonwealth can do this for one-quarter of the world's population. There are immense opportunities for engineers to increase the standards and prosperity of the countries of the Commonwealth and it also offers every kind of engineering experience for the enterprising.

Diesel Engineers and Users Association Annual Luncheon

On Thursday, April 13, the Diesel Engineers and Users Association held its annual luncheon at the Connaught Rooms, London, with the President, Mr. W. A. Parker, in the chair. Following the loyal toast Mr. A. G. Howe proposed the toast of the " Guests " coupled with the name of Professor Owen A. Saunders, B.Sc.(Eng.), M.A.(Cantab.), F.R.S., the president of the Institution of Mechanical Engineers, who replied and also proposed the toast of the " Diesel Engineers and Users Association." Professor Saunders reluctantly admitted that steam had now to give way to the diesel engine. He continued with a reference to the gas turbine and thought it wise to keep this young industrial member in the family. One of the difficulties of modern advances in technology was that the various developments brought forth new problems to be solved, and he specifically mentioned vibration, noise and exhaust smoke, to all of which he hoped the Association was paying due attention. In his reply Mr. Parker referred to the beginnings of the Association and to the part played by the high-speed engine, with its low capital outlay and low operating costs, in raising the standard of living throughout the world and particularly in the undeveloped countries.

Royal Institution of Naval Architects

ANNUAL SPRING MEETING

No. III—(*Continued from page 579, April 14*)

On the morning of Wednesday, March 29, the meeting continued with Mr. J. Turnbull in the chair and the presentation of :

HULL STRUCTURAL STEEL

The Unification of the Requirements of Seven Classification Societies

By G. M. Boyd and
T. W. Bushell, A.Eng. (Sheffield)

SYNOPSIS

The paper records that on June 26, 1959, the seven major classification societies agreed to unify their requirements for shipbuilding steel, and includes some historical notes of events leading to the final agreement. A table sets out the existing rules of the classification societies, and their individual reservations are listed, while the agreed Unified Requirements for Hull Structural Standard Tests are included in an appendix as is also a table giving the particulars of the five grades of steel adopted.

DISCUSSION

Mr. R. B. Shepheard, B.Sc.: I think it is worth recording that while the Western European shipbuilders compete with each other in all kinds of directions, on this particular issue they put up a united front some years ago.

This affected the Continental shipbuilders much more than the British. In those other countries certain ships were built with three different classes of steel, and when a new contract came along one never knew what differences might be involved. Therefore, from the shipbuilders' point of view, this was a very great achievement.

Concerning the revision before unification, I am reminded of what is stated in the paper about Lloyd's Clause 13. This was introduced in 1949, and in those days in Lloyd's Register we adopted a principle, which I am quite sure in the event has been proved entirely justified, of having some form of test to prove whether the material used will be sufficiently ductile under various conditions. At the same time we were faced with the problem of what was the structural standard. We wanted some form of specification which would give sufficient safeguards to the steelmakers to produce steel, not unduly expensive, which would be generally acceptable.

The authors have dealt very properly with the approach to unification. They refer to two basic principles upon which a grade of steel can be defined : (1) by specifying the metallurgy and manufacturing process, including composition, deoxidation practices, heat-treatment, &c.; (2) by specifying mechanical tests by which the quality of the finished product can be judged. The final outcome of all these discussions is a group of five specifications, including grades based on both methods of control, and this is one reason for arriving at five grades instead of the possible three mentioned earlier.

Naturally every classification society has felt obliged to register some reservations, and some are stated in the paper. I am disappointed with No. 11, that the Norske Veritas will retain their " NVW " grade in addition to the five " unified " grades since that introduces a further specification.

This work has been a very hard slog and it has produced something really helpful to all the interests concerned.

Mr. J. H. B. Chapman, R.C.N.C.: It was perhaps inevitable that, with all the effort throughout the world during the past decade or so to avoid brittle fracture in structural steel, there should grow up many new specifications, all designed for the same ultimate purpose. The cynic would say that the attempt to rationalise these was almost doomed to failure and, at best, that unification could be achieved only by the users of the best specifications agreeing to take the worst. Such a view is wrong, as is shown by the large degree of success which has now been achieved.

If specifications were decided entirely by the technical requirements of the user, the differences in the twenty-two specifications taken as the starting point for this exercise would still remain ; but we know that much more is, in fact, involved in negotiations leading to a specification which is acceptable both to user and manufacturer. It emphasis the amount of give and take and commonsense on all sides which must have been used to reach the measure of agreement now achieved.

At the same time, there may be some danger arising from the wide front on which standardisation has been attempted, the danger perhaps that technical standards might be lowered, and it is hoped that these unified specifications will be kept continually under review to ensure that the specifications are kept in line with the requirements of the day.

The Admiralty has a very strong interest in the development of shipbuilding steels in this country and we continue to take an active part, through the Admiralty Advisory Committee on Structural Steel, which is now holding a colloquium on fracture mechanics. Many of our problems are different from those in merchant shipbuilding, and we are perhaps not so strictly bound by cost. There are many points of similarity, and we are now reviewing our specifications to see how far we can line up with the unified specifications, whilst still safeguarding our own special requirements.

I endorse the view that both metallurgical and mechanical testing clauses are essential in a modern specification. This is particularly important in the higher strength ranges, since a good standard of weldability cannot easily be guaranteed by mechanical testing alone.

In a unifying exercise of this sort we cannot get into the specifications everything we may want, but I do regret that it has not been possible to specify yield stress for at least some of these steels. In Admiralty " B " quality steel we have a category 3 steel of very good notch toughness (30ft lb Charpy V notch at —30 deg. Cent.). To obtain this we must use a fully-killed, fine-grained steel and this naturally has a high yield/ultimate ratio. We use this as far as possible to give a high guaranteed yield strength and we take advantage of that in design to reduce scantlings. This to some extent enables us to make more efficient use of the steel to offset additional costs.

Mr. C. V. Manley : This paper is of particular interest because the whole history of structural steel for ships is practically within living memory. It is difficult to realise that up to 1914 iron ships were still being built, and there are many, between sixty and 100 years old, still afloat and working. Although Lloyd's Register first assigned an experimental class to a steel ship in 1867, it was not until 1888 that the first rules for steel ships were published, and the early attempts to control the quality of the material had crystallised into the form of actual rules. These rules were amended and brought up to date in 1902 and have remained as standard requirements with little change throughout this century until recently. Then, following upon the rapid developments in welded ship construction, during nine post-war years the seven major classification societies envisaged between them twenty-two different grades of ship steel.

More remarkable than the unified requirements, I think, is the fact that they have been unified. This represents something which has never been attempted before. The classification societies have conferred from time to time on the application of statutory requirements, but not on classification rules.

I can speak from personal knowledge of the difficulties which faced the working party. When they began their studies the different methods of approach, the different outlooks on the various problems, were such that it seemed impossible to reconcile them. By goodwill, however, a spirit of give and take and an urge to come to an agreement in the common interest, a set of unified requirements was produced which reduced the number of grades of steel from twenty-two to five.

The question of elongation alone presented great difficulty, and I recollect a complicated diagram produced by one of the French delegates, showing in graphical form the effect of the different requirements of the seven societies on this point.

Mr. N. E. Gundry, R.C.N.C., who showed a slide comparing Lloyd's grades " A " to " E " steels with the Admiralty mild steel and " A " and " B " quality steels, said : The Admiralty policy is to reduce the number of steel specifications to the absolute minimum, and to this end we have now only three steels for surface ships. The mild steel is the basic structural steel similar to Lloyd's mild steel, and the specification has not been revised for many years ; what we have in mind is to bring it into line with Lloyd's grade " A " or " B " steel. If we go into Lloyd's grade " A " we lose on ductility, and the spread of the u.t.s. is bigger. Is grade " B " steel available in this country, if we decide to withdraw our specifications in favour of this one and swallow the additional cost per ton?

The Admiralty " A " quality steel is notch tough and it has a yield of 16 tons per square inch just like mild steel. We have also the " B " quality for the reason that we need a medium tensile steel for use when we can really use the higher yield of 20 tons per square inch.

The unified series of steels has apparently reduced the number of specifications used by classification societies to five. It seems that the needs of the shipbuilding industry might be met by two steels only, i.e. grade " A " or " B " plus " E," one cheap and one expensive. Are we going to review these basic steels with a view to a further reduction in (say) five years' time?

Looking at the unified steels, no yield stress is mentioned at all. We normally design as close to the yield point as we can. We have already gone to a fully-killed steel. It does seem a pity that the societies have not a steel with a definitely specified yield point.

Monsieur P. Blanc, in a written communication which was read by Mr. B. N. Baxter, stated : Having been chairman of the working party dealing with the unification of

the requirements for hull structural steel, I would stress the frank and friendly spirit in which the work was carried out, despite the existence sometimes of major differences of technical opinion. There are many criticisms which may be made of the results of our work. The progressive changes in the requirements for the different qualities of steel are not very logical because they are the result of a compromise. It is, perhaps, regrettable that, as the result of reservations by different societies, the number of possible variations in the qualities of steel is still very large. Also the problem of what criteria to employ for the different qualities of steel, now defined, in the construction of ships, which is of interest to many shipbuilders, has not been studied.

These criticisms are justified and we do not pretend to have reached a final or definite conclusion. It is to be hoped that in the years to come the classification societies will make still more progress in the unification of steel specifications. At the moment the unified specifications will help to remove a large number of minor differences which complicate the task of steelmakers and will permit the finding in each country of equivalent material acceptable to each classification society.

Mr. B. N. Baxter, M.Sc. : Now that the unified requirements for steel have been agreed upon by the seven major classification societies, it should in some cases lead to a reduction of cost. In some countries when a classification society requires a type of steel similar to or slightly different from that turned out by the steelmakers, it pays very heavily indeed. But now that the various types of steel are brought into agreed categories which cover all the normal requirements there should not be any excuse in the future for any increase in tariff for the types of steel produced.

The second paper read on Wednesday morning, March 29, was :

THE BEHAVIOUR OF LONG DECKHOUSES

By J. C. CHAPMAN, Ph.D.

SYNOPSIS

The work described was undertaken in the Civil Engineering Department of Imperial College for the British Shipbuilding Research Association.

This paper, which follows an earlier paper on the same subject, aims to clarify certain aspects of hull-deckhouse interaction, the assumption being made that the stress distributions in the hull and deckhouse are respectively linear (but not collinear).

Graphs are plotted showing the influence of deck stiffness (foundation modulus) on deckhouse deflection and stress, and it is demonstrated that the influence is small where several bulkheads are present. Where no bulkheads are present the distribution of bending moment along the length of the deckhouse is found to depart greatly from that indicated by the simple theory of bending, even for a very high value of foundation modulus. Shear eliminating brackets are found to have the intended effect of greatly reducing deckhouse stresses.

The results of the present paper support an earlier suggestion that in view of the small influence of the foundation modulus when several bulkheads are present, and the practical difficulty of estimating the modulus, much useful information can be gained by assuming it to be zero. An example is worked on this basis for a ship having five bulkheads and the forces exerted by the bulkhead are found to be of the order of 100 tons on each side of the deckhouse.

Model experiments are described in which the influence of the deckhouse connections on the relative movement between hull girder and deckhouse was found to be considerable.

DISCUSSION

Mr. John Brown, B.Sc. : This is a first-class example of fundamental research and theoretical investigation fostered by B.S.R.A., research which I do not think any individual firm would have dreamed of undertaking. In these days there is very extensive criticism of the shipbuilding industry ; this is a very good example, which is not known to the public, of what it is doing. Such fundamental studies may seem to be a long way from practical politics in the shipyard ; but in this country we are pre-eminent in the production of large liners, and this particular piece of research is important there.

At the beginning of the work the concept embodied in the phrase " foundation modulus " was only beginning to be appreciated. Some of the early work showed that, because of the flexibility of the deckhouse, we should have problems at the top levels of the superstructure, and the problem there might be eased because of the break back in the stress diagram ; it is an assuring feature of the work of Dr. Chapman that that wrong impression has been to some extent corrected. This break back does not always occur and in some cases we can have a stress at the top level of the deckhouse, which is the one indicated by the standard method of calculation. That alone is a valuable indication of what we have to look out for in the stresses in these long superstructures.

I shall be glad if Dr. Chapman will elaborate on the point about the effect of the number of bulkheads. In the diagram showing the variation of deckhouse stress with foundation modulus, at a high value of the foundation modulus the ratio of the stress at the top of the deckhouse to the calculated stress is greater than one where there are two, three and four bulkheads, but with five bulkheads it comes down to something less than one. In the practical example, we find that in a ship with five bulkheads this ratio is greater than one in certain sections. Admittedly the foundation modulus in that case has been taken at zero. I am not clear whether there is some other effect, between the fundamental diagram and the practical applications of it.

Dr. W. Muckle, M.Sc., Ph.D. : The question arises as to whether or not we want to make a superstructure effective. I have always maintained that we ought to make it effective ; it is at the greatest distance from the neutral axis of bending and therefore can make a great contribution to the section modulus of the ship. This is even more true when dealing with an aluminium superstructure ; it is an expensive material and I reckon we should get out of it everything that we can. I certainly recommend the idea that the superstructure should be made as near 100 per cent effective as possible.

The author has dealt with the possibilities of flexible connections between the deckhouse and the main structure. Some years ago I dealt with this in a short paper to the Institute of Welding, on welded aluminium deckhouses, and I can see there is a possible merit in having a floating superstructure ; you get over the problems of discontinuities. I agree that there may be great difficulties in attempting to carry this out ; you have considerable relative movement between the hull and the deckhouse and it would be difficult to sort it out practically. On the other hand, if you want to make the superstructure ineffective I agree that this is a better way than having expansion joints. The use of expansion joints brings discontinuities, which we are trying to avoid.

I am particularly interested in the possible flexbility of the joints between the superstructure and the main hull. Dr. Chapman has shown that it is possible for slips or at least distortion of the joint to occur. I would mention some work which has been carried out by the Aluminium Development Association—it has not been published yet—on the transmission of strains between steel and aluminium. So far we can say that tension is transmitted without any loss in going from one material to the other. I think that will be so in the case of the full scale ship, where we have tension between the aluminium superstructure and the steel hull. The initial experiments were made with rivets and bolts, and as the rivets did not seem to be sheared I suggest the forces may be transferred without slip.

Dr. I. M. Yuille : With regard to the effect of bulkheads, it is stated in conclusion 3 that : " Where several bulkheads are present the deckhouse behaviour, and the bulkhead forces, can be predicted with reasonable accuracy by assuming that the foundation modulus $k=0$." This may cause a little confusion to those who have not studied the work carefully. I would like to suggest that it be re-worded as follows : " If several bulkheads are present the foundation modulus of deck beams—k—has little effect on the results because of the overwhelming importance of the rigid connections in way of the bulkheads. For purposes of calculation the value assumed for the deck beam foundation modulus is therefore unimportant, and it is convenient to assume that $k=0$."

With regard to shear eliminating brackets, if you eliminate shear you increase the stress in the hull to quite a considerable extent. In my opinion it is much better to make the superstructure fully effective. Why not let it take part in the bending of the ship? Dr. Muckle has mentioned an aluminium superstructure. I think the point may be made that in effect, by fitting an aluminium superstructure, you are fitting an expansion joint. Although not, in fact, fitting an expansion joint you are reducing the stress of the superstructure, and I think this is probably one of the best ways of doing it.

Dr. J. B. Caldwell, B.Eng., Ph.D. : In this paper there is a table showing the variations in the stress ratio at the centre sections with different numbers of bulkheads. It shows that for a superstructure which covers three bulkheads we can get a very significant increase in the bending stress at the top of the superstructure ; the author's figure for the stress ratio is 1·655. This is rather high by normal standards, and I ask how much credence we can give to that particular figure. It seems to me that we may considerably overestimate the stresses on superstructures.

I feel that, in view of the work of this kind which has been done, we should have a pretty good understanding of the overall stresses on superstructures, of calculating the general level of stress distribution in the superstructure itself, and its effects. But the matter to which more attention needs to be given now is the concentration of stress at certain points due to the inevitable discontinuity, and the reduction of stress concentrations.

Mr. L. Woollard, M.A. : Following Dr. Caldwell's remarks concerning trouble due to stresses at the end of a superstructure, I remember some work on H.M.S. " York " about thirty years ago. There was a forecastle end in a region of high stresses, and the structural stresses in that ship were of the order of 11 tons per square inch nominal. We managed to break down the main structural stresses satisfactorily where the forecastle stopped, but parts of the superstructure of the ship suffered.

Dr. Johnson : A point I wish to raise concerns the various ratios for the stresses at the top of the deckhouse compared with

those calculated, assuming that the whole section behaves according to simple beam theory. Some of the ratios of the stresses at the centre-length of the deckhouse, given in the table referred to by Dr. Caldwell, might appear to be disconcerting. They might seem even more disconcerting if reference is made to Dr. Chapman's 1957 paper to the Institution, on "The Interaction between a Ship's Hull and a Long Superstructure," in which he shows that for all examples containing more than two bulkheads the stress ratios are all in excess of unity at some position within the length of the deckhouse.

It seems a pity that the values quoted for the variations of stress are not compared directly with experimental results. The only experimental results given in the paper refer to deflections from which it is not usually easy to make accurate deductions on the stress gradients. However, if we look at his diagrams of relative deflection between hull and deckhouse for the three bulkhead case, it appears that the experimental data differs quite appreciably in magnitude from the calculated values and suggests that at the centre bulkhead position the relative curvature between the hull and the deckhouse was very small indeed. One might conclude from this that the stress ratio which was calculated to be 1·655 was not confirmed by the experiment and that it might be nearer to unity.

My own observations on ships of various types have not revealed stress gradients in the deckhouses of the magnitudes indicated by the author's analysis, although the trends have sometimes been clearly indicated. In ships having deckhouses of varying lengths it is my experience that the stress at the top of the deckhouse at any point within its length is generally less than that predicted by simple beam theory. This may well be due to the fact that the actual structures usually bear little resemblance to the idealised case and that perhaps shear lag is of some consequence even in fairly long deckhouses.

(To be continued)

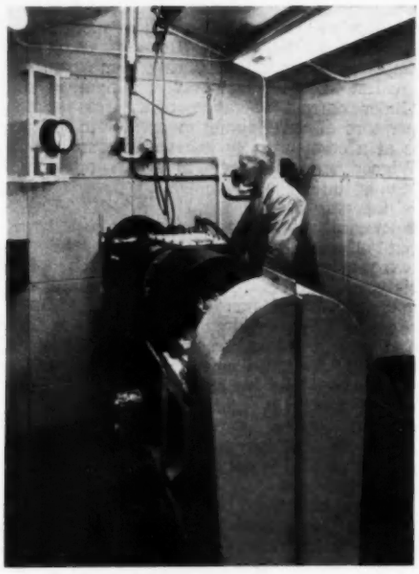
London Transport Works Reorganised

A COMPREHENSIVE modernisation and reorganisation programme costing about £1,500,000 has now been completed at the Chiswick works of London Transport. When this works was put into service in 1921 it was designed to handle the overhaul requirements of 4000 vehicles and it was extended before the late war to meet the needs of a fleet of about 6000 vehicles. After the war the size of the bus and coach fleet increased rapidly and the designs of the vehicles became more complex. This necessitated a substantial increase in overhaul facilities to meet which the Aldenham works* was opened in 1956. At the same time it was planned to concentrate the overhaul of mechanical and electrical units at the Chiswick works, the reorganisation of which was put in hand.

The units overhauled at Chiswick include the principal electrical and mechanical assemblies such as engine, gearbox, axles, springs, batteries, starters, etc., which fail in service. It should be mentioned here that—other than in the complete overhaul a vehicle undergoes at the end of each four years in service at Aldenham—a system of periodic or mileage overhaul of units is not practised by London Transport. For this reason the units handled at Chiswick are those which have failed in service and are beyond the facilities of the service garages, where the work is now restricted to running maintenance and the changing of units or sub-units.

Under the work flow system laid down, the same general lines are followed with all units—engines, gearboxes, axles, differentials, fuel injection equipment, steering gear, brake gear, starters, dynamos, &c. Upon delivery to a reception area the units are sorted and despatched, usually on pallets or special mobile cradles, into their appropriate overhauling section at a steady rate according to the capacity available in the shop. The first step before overhaul is a primary wash to remove all external dirt prior to stripping down into sub-assemblies and parts corresponding to a manufacturer's main assembly. The sub-assemblies are then dismantled into components which are thoroughly cleaned before passing on to pre-view stations.

At these pre-view stations the parts are placed in one of three classes—fit for re-use ; capable of being re-conditioned ; and scrap. Parts fit for re-use are sent to pre-assembly control stores and replacements for those that are scrapped are drawn from a main stores and sent to the pre-assembly control stores so that the parts stock is maintained at the required level. Parts capable of being re-conditioned are sent to the appropriate section of the works from which they are returned to the pre-assembly control stores after the necessary work has been carried out.



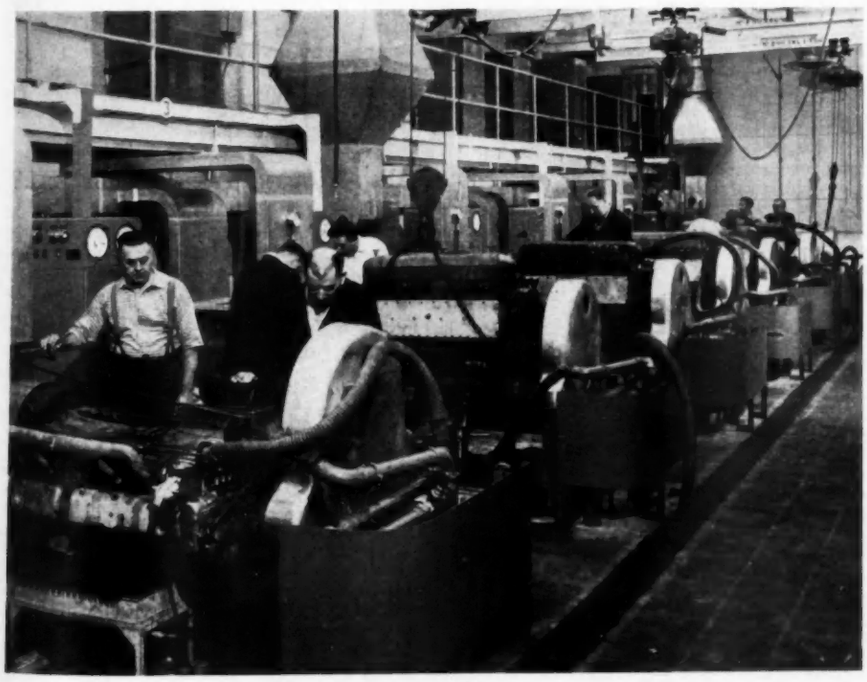
Testing rebuilt gearbox in soundproof cabinet

Engines are responsible for about half the work carried out and are therefore by far the most important units dealt with at Chiswick. Some 60 per cent are A.E.C. engines for RT-type buses and a recent review showed that an overhauled engine of this type contained 20 per cent new parts, 63 per cent reconditioned parts, and 17 per cent parts which needed no more than cleaning to make them serviceable.

Parts earmarked for reconditioning are held in the pre-repair stores and are sent into the reconditioning shops in suitable production batches unrelated to the units from which the parts were stripped. The principal reconditioning sections are : a plating shop, where worn surfaces are built up by electro-deposition ; a welding shop, where worn surfaces are built up by gas or electric welding ; a metal spray shop, where parts, after having been shot blasted, are built up by the metal spray process ; and a general machine shop. In this machine shop parts which have been built up are subjected to operations equivalent to the final operations during manufacture to bring them back to new condition. Components which have not been built up are similarly re-worked in the general machine shop to bring them to a serviceable condition, usually to a smaller dimension than that of the new parts, in accordance with a system of first, second, third, &c. standard sizes. Alternatively, these parts are dealt with in bench reconditioning shops where they are made serviceable by hand operations, or a degree of re-assembly is carried out.

When components have been reconditioned, they are inspected and sent to the pre-assembly control stores, from which they are drawn by the various unit assembly shops to make up complete units. No distinction is made between new, secondhand "fit for issue," and reconditioned parts drawn from the stores for assembly purposes because it is a fundamental principle that the standards of repair and inspection shall be such that the service life of an overhauled unit shall not be less than that expected from a new one.

* See THE ENGINEER, November 2, 1956.



Rebuilt engine test-house

SHORTER REPORTS

Wigner Release on "Bepo" Reactor, Harwell

A SUCCESSFUL release of Wigner energy was effected on the "Bepo" reactor at Harwell about two weeks ago. This Wigner energy, which is stored in the crystal lattice of graphite by displacement of atoms during bombardment is greatest when the temperature is relatively low. Under normal operating conditions the temperature of the graphite moderator in "Bepo" is at a comparatively low temperature and the Wigner stored energy must be released at regular intervals by controlled heat treatment of the graphite.

Release of Wigner energy has been carried out successfully on the "Bepo" reactor on two previous occasions: the first was in 1954, six years after the initial start up of the reactor; and the second was in 1958. On the third occasion Wigner energy release began at 06·45 a.m. on April 8 and was considered to be complete by 7.30 p.m. the same day. The operation was carried out by externally heating the air stream which is normally used to cool the reactor. During the release the heated air was passed through the reactor for about twenty-two hours at about 9 per cent of the normal operational flow rate.

Throughout the operation the reactor was run at a very low power level (about 50kW) so that the burst cartridge detection equipment could be used. The nuclear heating so produced was negligible in comparison with the air heating and had no appreciable effect on the progress of the release.

Preparatory work had been proceeding for some weeks before the reactor was shut down for the final stages of preparation. The condition of the reactor graphite was investigated before the release by sampling techniques; additional instrumentation, including 350 thermocouples for temperature measurement, was provided so that the course of the release could be observed in detail.

Research on Flow Conditions in Boiler Tubes

EXPERIMENTAL work on the fundamental factors influencing circulation in high-pressure boilers was described in a paper presented at a meeting of the Institution of Mechanical Engineers* in London recently. This research project was sponsored by the Water-Tube Boilermakers' Associated and the work was done in the Engineering Department of the University of Cambridge.

The main object of the research was to establish experimental data relating to the flow conditions and pressure drop of high-pressure steam-water mixtures flowing along heated and unheated pipes, in both horizontal and vertical positions. Simple boiler circulation theory is based on the assumption that the steam-water mixture moves as a homogeneous fluid. But there is little existing data on effects of relative velocity between the steam and water phases, a phenomenon which is known to exist under actual flow conditions in a boiler circuit. The results obtained from this work are applicable to other kinds of evaporative heat exchangers.

The paper was in three parts. The first part dealt with the high-pressure experimental plant and its associated instrumentation which was installed on the site of a disused aircraft factory on the outskirts of Cambridge. Briefly, the installation consisted of a closed-circuit test loop fabricated from mild steel, through which water at saturation temperature was drawn from a steam-water drum and was circulated by a glandless submersible pump. This circuit included a metering orifice and a throttle valve for adjustment of flow rate. Before passing through the test section of the circuit the water traversed an electrical preheater, the power being adjusted to bring the water exactly to its local saturation temperature at inlet to the test section. Provision was made for test sections of ½in, 1in, or 1½in bore to be installed in any of four angular positions, but the work described covered only the 1in and 1½in pipes in the horizontal and vertical positions. The test section was heated electrically by mains-frequency induction heaters.

The work required the development of special differential manometers and differential thermocouples suitable for the accurate measurement of small differences in pressure and temperature at high fluid pressures. Gamma-ray absorption equipment was used to make measurements of the apparent density of the two-phase mixture within a cross section of the tube at the test-section outlet, from which estimates could be obtained of the relative or "slip" velocity between the two phases.

Part II of the paper dealt with the analysis of the experimental results obtained from measurements of the absorption of gamma-rays in their passage through the two-phase mixture at outlet from the test section. The results of tests on the 1½in bore pipe were examined first, although they were the last to be carried out. In these tests the tube cross section was scanned by a narrow pencil of rays from a collimated beam, and scintillation-counter equipment was used to measure the intensity of the emergent radiation. Preliminary tests involving scans along a number of chords of the tube cross section gave information on the density distribution of the fluid within the cross section; this proved to be different for the vertical and horizontal pipes. Data from these readings enabled the main series of tests, during which pressure-drop readings were also taken, to be carried out with a single scan along the tube centre-line only. From the readings taken during the latter tests the area dryness-fraction (void fraction) and slip velocity ratio were calculated and correlated as functions of the mass dryness-fraction. The paper then gave a brief presentation of the less satisfactory results obtained on the 1in bore pipe with full-area scanning by an uncollimated beam using an ionisation chamber as detector. The foregoing correlations were finally used to calculate slip correction factors by means of which the acceleration and gravitational pressure-drops calculated according to homogeneous theory may be corrected for the effects of slip.

The third part of the paper gave an analysis of the pressure drop measurements made on the 1in and 1½in bore pipes in the vertical and horizontal positions, with particular attention to the frictional pressure drops in the horizontal pipes and to comparisons between the experimental results, the values predicted according to the homogeneous theory, and the values predicted after correction for the effects of slip according to the methods outlined in Part II of the paper.

In their conclusions the authors stated that, over the range of variables covered in the tests, the experimental pressure drops at 2100 lb per square inch absolute were close to the values predicted by homogeneous theory for both horizontal and vertical pipes. For horizontal pipes at the lower pressures, homogeneous theory gave closer prediction of the pressure drop for heated than for unheated pipes, owing to the opposing effects of two-phase flow conditions on the frictional and acceleration pressure drops in the heated pipes. For vertical pipes at the lower pressures, the experimental pressure drops were significantly greater than the values predicted by homogeneous theory. The gravitational contribution to the total pressure drop was dominant, and it was influenced significantly by the effects of slip. Closer prediction was achieved by introduction of the slip correction factor presented in Part II of the paper.

In short, the authors conclude that the experiments described in the paper have yielded extensive information on the pressure drop of steam-water mixtures at high pressures and have illustrated the limitations of homogeneous theory in estimating two-phase pressure drops. The work has also provided new data on the void fractions of two-phase mixtures and on the effects of slip.

* "Experimental Study of the Flow Conditions and Pressure Drop of Steam-Water Mixtures at High Pressures in Heated and Unheated Tubes," by R. W. Haywood, G. A. Knights, G. E. Middleton and J. R. S. Thom.

Support for Club Flying

A £100,000 FUND to encourage British aviation through the medium of the flying club movement has been set up by the Society of British Aircraft Constructors, Ltd., in association with Shell-Mex and B.P., Ltd., to assist private flying and gliding clubs in the United Kingdom by granting loans at low rates of interest for the purchase of aircraft and ancillary equipment and the provision of essential facilities.

Shell-Mex and B.P. are contributing £25,000, and other member companies of the Society, £75,000.

The Fund will be administered by a Committee representing the Society and Shell-Mex and B.P., Ltd. Mr. Basil Meads has been appointed secretary of the new Fund.

Small Parts Copying Lathe

A COPYING lathe for work up to 1in diameter is now made by Myford, Ltd., of Beeston, Nottingham, for the high-speed repetitive turning of small workpieces. The lathe has a hydraulic carriage traverse and a single control lever provides cutting feed and rapid traverse in either direction. A feed rate control lever provides instantaneous variation of feed rate which can be altered whilst turning is in progress.

The "Mini-Kop" hydraulic copying equipment fitted works with a stylus pressure of under 2 lb and unhardened templates can be used for small batch work.. There are two angles of approach, the maximum tracing angle being 30 deg. with the slide at 55 deg. and a minimum angle of profile of 60 deg. with the slide at 90 deg. Drive from the 2 h.p. motor on this machine is transmitted through interchangeable pulleys giving eight spindle speeds, from 500–4085 r.p.m.

[Reply Card No. E6584]

Alloy-Diffused Transistor for V.H.F.

FULL-SCALE production has begun of the AFZ11 alloy-diffused transistor introduced by Mullard, Ltd., Mullard House, Torrington Place, London, W.C.1, for low-noise amplification at 100 Mc/s. The alloy diffusion technique used for the AFZ11 enables the intrinsic base resistance and feedback capacitance to be kept to very low values, and at 100 Mc/s the transistor will give a power gain greater than 10dB. Since the noise figure at this frequency does not exceed 6dB, the AFZ11 is recommended for service in v.h.f. communications equipment. Maximum collector-base voltage of the device is −20V and the maximum collector-emitter voltage is −10V at the full current rating of 10mA. Collector leakage current is 1 microampere (typical) with collector-base voltage of −6V, at a temperature of 25 deg. Cent. At the same voltage and temperature, and with a collector current of 1mA, the current gain is typically 70, and f_1 is typically 140 Mc/s. The maximum junction temperature is 75 deg. Cent. and the thermal resistance is 0·6 deg. Cent./mW, permitting a dissipation of 50mW in an ambient temperature of 45 deg. Cent.

[Reply Card No. E6585]

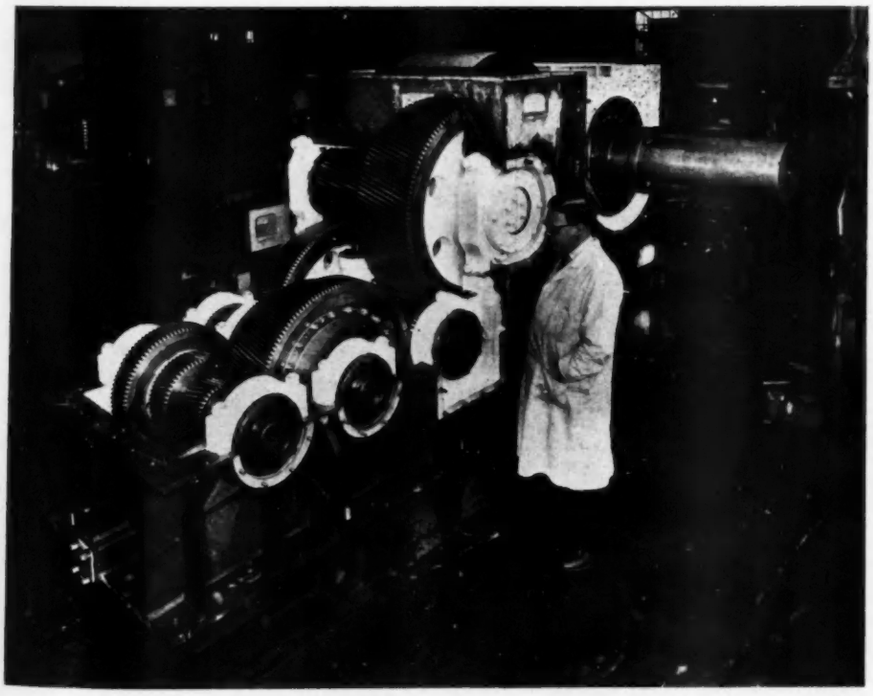
Picking-up and Paying-out Gear for Cables

THE gear installed in cable ships for the purpose of laying new cables and for picking up cable during repair operations, calls for equipment of robust design, to withstand the heavy strains imposed, and for accurate control. When paying out cable either over the bow or over the stern in deep water a tension of up to 8 tons at a laying speed of 8 knots can be attained and this has to be taken by braking gear adequate to withstand such a load without failure. Thus the brakes must be capable of continuously dissipating nearly 500 h.p. When engaged in repair work to break out a cable which has lain on the sea bed for a number of years may set up a tension load of about 30 tons at a speed as low as ¼ knot, a lower tension and a higher speed being possible once the cable has been broken out and in shallow water. The usual arrangement of cable gear is two horizontal axis capstans with the open end inboard, generally powered by a reciprocating steam engine, driving through open gears and manually operated dog clutches. The gears are fitted with direct-acting wood and water-cooled steel band brakes and in addition a hydraulic brake driven through flexible couplings.

The development of the Telcon/Hindmarch picking-up and paying-out gear represents a complete breakaway from the traditional and it has been designed by T. Hindmarch and Co., Ltd., for the Telegraph Construction and Maintenance Company, Ltd. and built by Modern Wheel Drive, Ltd. This gear has been constructed to a specification which was originally laid down by the Post Office and is now generally adopted. The specification requires that when paying out any tension load of up to 8 tons at any speed up to 8 knots should be withstood and that the loads to be taken when picking up are up to 30 tons, 15 tons, and 7½ tons at speeds up to 1 knot, 2 knots and 4 knots respectively, all ratings being continuous. Four pairs of gears have been ordered; the first pair of mark TH4C Telcon/Hindmarch gears has been delivered for installation on board the Post Office cable ship "Alert" and the second pair, one of which we illustrate with covers removed, has been completed to the order of the French Department of Communications for its cable ship "Marcel Bayard." The third and fourth pairs are for Finnish and Russian cable ships. The "Marcel Bayard," which was laid down at the yard of Augustin Normand at Le Havre in April of last year, has a length of 377ft 2in by 51ft 2in beam, a deadweight of 4260 tons, a speed of 13·5 knots and can carry 1025 miles of cable weighing about 2900 tons.

The gear is totally enclosed and carried in a fabricated frame and is built to the standards now adopted for main propulsion gearing. The gear consists of an input shaft, a clutch shaft, the first intermediate reduction shaft, the second intermediate reduction shaft, and the final drive which is a 15in diameter shaft carrying an overhung 7ft diameter cable drum. Power is supplied by an electric motor which develops 250 h.p. at 850 r.p.m. and drives the input shaft through two No. 24 V.S.G. motors working in parallel. The input shaft, which has roller bearings at the drive end and roller bearings plus a duplex split thrust bearing to take the helix thrust at the other end, carries four pinions, the smallest of which is solid with the shaft, the others being keyed. These pinions mesh with Hindmarch/M.W.D. oil-operated clutches, of which three are used for picking-up duties, while the fourth is used for paying-out purposes when the V.S.G. units are used as pumps to provide the braking effort. The bearings carrying the clutch shaft are similar to the input shaft arrangement. Both input shaft pinions and the clutches have a helix angle of 11 deg. and the overall gear ratios are 182, 91, 46 and 20 to 1. The pinion on the clutch shaft and the wheel on the first intermediate reduction shaft have a helix angle of 20 deg., while the pinion on the same shaft has a 15 deg. helix angle as has the wheel on the second intermediate reduction shaft. The pinion on the latter shaft, is solid with the shaft and both it and the final drive wheel have a helix angle of 10 deg. Roller bearings are used throughout the gears and provision is made for the heavy thrust set up as the turns of the cable move sideways on the drum. The first intermediate reduction shaft has bevel gears, located between wheel and pinion, to take an auxiliary drive.

[Reply Card No. E6591]

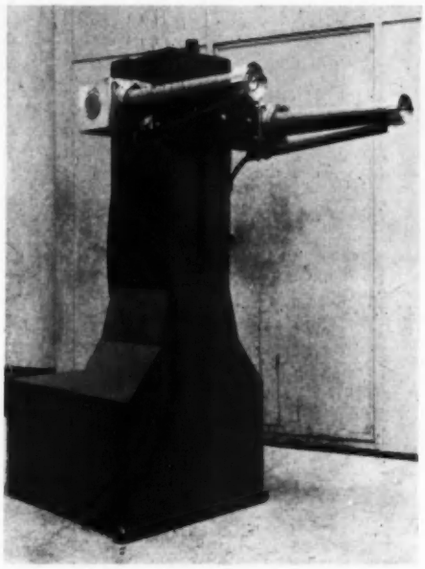


One of a pair of Mark TH size 4C oil-operated cable gears

Electrostatic Paint-Spraying Equipment

AN electrostatic paint spraying system named the "Megastatron," introduced by S.A.M.E.S. (G.B.), Ltd., is to be marketed in this country by Aerostyle, Ltd., Sunbeam Road, London, N.W.10 A development of the company's "Statron" portable electrostatic spraying equipment, the new system is completely automatic and is designed for use in large-scale production. The equipment includes one 150kV electrostatic generator, two atomisers, a set of high and low-tension connection cables, and a set of six atomising heads of differing diameters. From this basic plant and a range of ancillary equipment, an electrostatic painting installation of any size can be assembled to suit a user's requirements.

In operation, paint at low pressure (about 10 lb per square inch) is delivered to the spray gun together with electrical power at 150,000V and 220V/380V. The lower voltage is used to drive a small electric motor incorporated in the gun and the higher voltage, from the electrostatic generator, to charge the paint. Paint is led to the charged head of the atomiser which is in the form of a cylindrical cup. This cup is rotated at high speed by the motor so that the charged paint is thrown out of the end of the cup in an atomised spray due to the centrifugal force imparted to it. Because the paint particles thus produced are similarly charged, they are mutually repellent and this helps in the dispersion of the paint. In this way the equipment produces a cloud of finely dispersed, negatively charged paint particles which are attracted to any earthed object in their path. Because of this, overspray is virtually eliminated and the volume of solvent vapour required is substantially reduced. It is claimed that reductions in paint consumption from 40 to 80 per cent, depending on application, can be expected with electrostatic paint spraying as compared with conventional paint spraying.



Electrostatic paint-spraying equipment for large scale production

The generator itself is designed for continuous industrial operation and the voltage it produces is variable from zero to its rated output. The plant is completely safe because the maximum current is only 400 microamperes, or 200 microamperes to each atomiser.

The atomisers are fitted with totally enclosed electric motors and there are three lateral paint inlet tubes to enable colour to be changed rapidly when required. The three heads supplied with each atomiser have diameters of approximately 4in, 6in and 8in to give paint outputs of 5½, 7¾ and 11 gallons per hour respectively. These figures correspond to painted areas of 2700, 3800, and 5400 square feet per hour.

The accessories that can be supplied include an adjustable paint feed system comprising two variable output pumps controlled by speed regulators and a paint container fitted with an agitator which ensures paint homogeneity.

We illustrate one of the three types of supporting device available for the atomisers. A fixed ground support enables the atomiser to be raised and lowered and tilted at an angle and adjustable supports enable the atomisers to be moved horizontally and vertically.

[Reply Card No. E6592]

SHORTER REPORTS *(continued)*

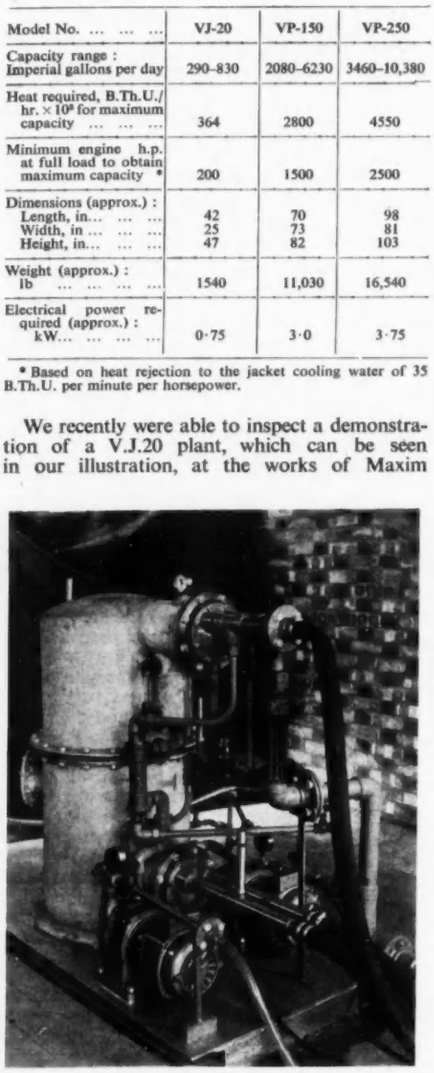
Heat Recovery Unit

AN evaporating and distilling unit has recently been introduced by A.M.F., Ltd., and is built by the Maxim Division of the company. The main intention of this Maxim "Aquavap" heat recovery distilling plant is to utilise the waste heat in the water in a diesel engine cooling system to produce a supply of potable fresh water and so greatly improve the thermodynamic efficiency of the power unit. At present three designs of varying capacities are available and the main particulars, which are intended only as a general guide, are set out in the accompanying table.

Model No.	VJ-20	VP-150	VP-250
Capacity range : Imperial gallons per day	290–830	2080–6230	3460–10,380
Heat required, B.Th.U./hr. × 10^3 for maximum capacity	364	2800	4550
Minimum engine h.p. at full load to obtain maximum capacity *	200	1500	2500
Dimensions (approx.) : Length, in...	42	70	98
Width, in	25	73	81
Height, in...	47	82	103
Weight (approx.) : lb	1540	11,030	16,540
Electrical power required (approx.) : kW...	0·75	3·0	3·75

* Based on heat rejection to the jacket cooling water of 35 B.Th.U. per minute per horsepower.

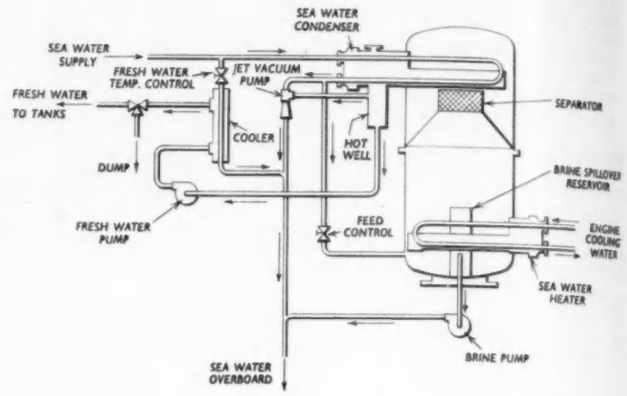
We recently were able to inspect a demonstration of a V.J.20 plant, which can be seen in our illustration, at the works of Maxim



Mark VJ-20 Maxim-"Aquavap" distiller on test

Silencers, Ltd. As will be seen from the table this is the low capacity model. The evaporator shell is constructed of glass-fibre-reinforced plastic the supply lines being of "Durapipe." For installation purposes the V.J.20 is supplied as a packaged unit complete with raw-water heater, distiller, condenser, vacuum, waste-water and fresh-water pumps and controllers, and necessary gauges, &c.

The shell consists of three parts fastened together with cadmium plated bolts. Raw water is supplied to the lower section or reservoir where it is boiled at a low temperature of about 125 deg. Fah., since the evaporator operates under a vacuum, and scale formation is practically eliminated. The vapour rises through the cone



Flow cycle of heat recovery evaporator

shaped middle section fitted with a separator, and the purified vapour enters the upper chamber where it is condensed and the resultant fresh water collects in the hot well. Our diagram shows the flow cycle of the evaporator in which engine cooling water is passed through hairpin heater tubes to heat the raw water in the reservoir forming the bottom section of the shell, and the drop in temperature between the ingoing and outgoing engine cooling water is about 20 deg. Fah. The level of water in the reservoir is maintained by a built-in weir, the overflow being pumped overboard. Seawater is circulated through the distillate condenser tubes and part of the supply is used to cool the fresh-water which is pumped through the cooler on its way to storage tanks. Some of this cooling water after passing through the condenser is used to provide the raw water and passes through a flow indicator and feed meter into the evaporator shell. The remainder passes through a jet vacuum pump, which removes air and non-condensible gases and creates a vacuum of about 20in in the evaporator shell, and is then discharged.

The required degree of purity of the fresh water is controlled by an electric salinometer in which a probe sends a signal to a controller which, when the fresh water is of the correct degree of purity, causes a solenoid-operated valve to open and allow the water to pass to storage. Should the water not be to standard the solenoid-operated valve closes and pressure build up causes a dump valve to open and the foul water is discharged.

Although the shell of the Maxim "Aquavap" on test was built of glass-fibre-reinforced plastic, shells are also available in monel metal. Corrosion resistant material as dictated by the operating conditions is used in the construction of the pumps. Aluminium brass tubes are used for the heat exchangers while the piping can be of cupro-nickel or plastic.

[Reply Card No. E6601]

Induced Draught Cooling Tower Fan

SUCCESSFUL running tests have been completed on the prototype of an induced draught cooling tower fan developed by the Airscrew Company and Jicwood, Ltd., Weybridge, in conjunction with Brook Motors, Ltd., Huddersfield. These fans are to be made in three forms—for vertical operation with the impeller above the motor, vertical operation with the impeller below the motor and for horizontal mounting.

The motors are rendered waterproof by sealed endshields and the fitting of a generously proportioned drip ring between the shaft and endshield which prevents water draining into the shaft clearance space when the motor is set below the impeller. When the motor is set above the impeller a rotating finger and shroud keeps water out of the shaft clearance space. A drain hole at the lowest point of the motor prevents accumulation of internally condensed moisture and the windings are proofed against condensation by two coatings of resin in addition to the standard resin dip and bake finish. The motor carcase is protected against corrosion by dipping its parts in etch primer, hot spraying with synthetic resin paint and applying two coats of bituminous paint upon assembly.

Either plastic-covered wooden or aluminium alloy impellers can be fitted to the fans. The wooden impellers are covered with a thick impervious layer of plastic impregnated into the wood fibres on its underside. The cast iron hubs carrying these impellers are zinc sprayed and finished with two coats of aluminium pig-

Induced draught cooling tower fan on test rig. A water jet is attached to the left leg and the spray caused by the rotating fan is clearly shown

mented bitumen paint. Bolts used in their assembly are of stainless steel or plated to prevent corrosion and all bolt holes and surfaces between the wooden boss and hub flanges are sealed by rubber gaskets. Steel parts used with the metal impellers of corrosion-resistant aluminium alloy are zinc plated and all parts are coated with aluminium pigmented bitumen. Drain holes are provided in all locations on an impeller where water could accumulate (either statically or under centrifugal action) so that no loss of balance of impeller will occur. The short cylindrical ducts of welded steel plate and the rectangular tubular arms extending in to support the motor and impeller assembly are adequately protected against the effects of corrosion.

Our illustration shows the prototype fan which was subjected to a continuous ten days test in a rig to simulate working conditions. It was fitted with an adjustable-pitch detachable-blade aluminium alloy impeller.

[Reply Card No. E6602]

Epicyclic Gears for Mine Hoists

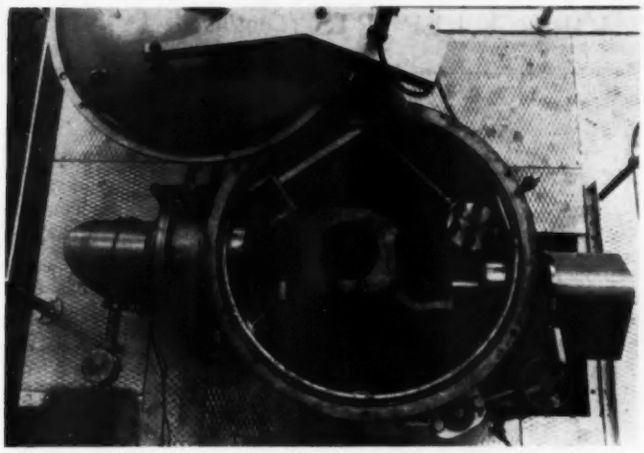
PARTICULARS have been received from W. H. Allen Sons and Co., Ltd., Bedford, of the Allen-Stoeckicht epicyclic reduction gears which have been supplied for two new sets of tower-mounted mine winding equipment being installed at the Cardowan Colliery, Glasgow. These double-reduction sets each incorporate two epicyclic gear trains, the first train being of star design, in which the planet wheel carrier is held stationary. The second train is of planetary design with the annulus system held stationary. The reduction effected is from 713 to 63·1 r.p.m., at which speed the maximum torque is equivalent to 1320 h.p., and each gear is designed to run continuously at this power.

One of the gears is shown in the illustration below and its construction can be seen in the accompanying drawing. Each gear has at its driving end a double-gear-toothed flexible coupling sleeve, taking the drive from the motor to the sunwheel of the first train. The sunwheel itself is not carried in bearings, but is supported by the four planet wheels, and it centralises between these wheels under the influence of the tooth reaction forces. The planet wheels revolve on white-metal-faced spindles supported by a planet-wheel carrier, which, in turn, is rigidly bolted and dowelled to the gearcase. The rotating annulus (outer ring) system is flexibly coupled (by toothed couplings) to the sunwheel of the second train, in which the annulus system is flexibly coupled to the gearcase. From the floating sunwheel the drive is transmitted through five planet wheels to the rotating planet-wheel carrier. This carrier has no main bearings, but is rigidly bolted to an output stub-shaft, which is in turn bolted to the winder drum shaft. The planet-wheel carrier of the second train is thus overhung from the bearings of the winder drum. The compact construction of the gear can be appreciated from the fact that the first-train annulus has a diameter of 22½in, and the second a diameter of 30½in.

The maker points out that apart from the advantages of reduced weight and space, one of the advantages of epicyclic gearing for mine winding installations is the relatively large amount of misalignment that can be tolerated. Tower-mounted winders supports are relatively flexible and with two winders in one tower it is possible that an over-wind on one will cause a deflection of the support of the second winder drum. The incorporation of gear-toothed flexible couplings in these gears enables this deflection to be accommodated without difficulty. In the case of the gears supplied for Cardowan colliery the coupling systems between the first and second trains and between the annulus system of the second train and the gearcase, have been designed to allow for a deflection of the winder drum bearing support, remote from the gear, of ¼in.

The gears are being supplied by W. H. Allen Sons and Co., Ltd., through Walmsey Brothers, Ltd., Wigan, the manufacturers of the hoists, and A.E.I., Ltd., of Rugby, the firm responsible for the main electrical equipment and co-ordination of the contract.

[Reply Card No. E6611]



Vacuum melting induction furnace with a coil assembly of 100 lb steel capacity

Vacuum Melting Furnace

THE medium size induction furnace for vacuum melting made by Edwards High Vacuum, Ltd., Manor Royal, Crawley, Sussex, is now available with a coil assembly of 100 lb steel capacity. The melting capacity of the furnace may now be altered by the use of either a 28 lb, 56 lb or 100 lb coil assembly, all of which are fully interchangeable.

When pouring the assembly lip tilts through a rotating coaxial seal carrying the power and water supplies to the coil. The furnace is contained within a vertical water-cooled vacuum chamber which incorporates addition mechanisms, immersion pyrometers, a bridge-breaking mechanism, internal light and a support platform for the ingot mould. The chamber interior is viewed through a window fitted with a wiper and radiation shield attachment which keeps the window substantially free of metal deposits.

The charging mechanisms provided enable one-third of the bulk charge and a random choice of six alloying additions to be added to a melt without breaking the vacuum. Accurate temperature measurement up to 1800 deg. Cent. is provided by two immersion pyrometers. The lid " lift and slew " mechanism is hydraulically operated by a hand pump on the furnace platform and obviates the need for an overload hoist for lifting the lid.

The standard furnace is fitted with a high capacity vapour booster pump designed specially for vacuum processes where large quantities of gas are evolved and low ultimate pressures are required in minimum time. The photograph we reproduce shows a furnace installed at Sanderson Brothers and Newbould, Ltd., of Sheffield, and in it the 100 lb capacity coil assembly and new lid lifting mechanisms can be clearly seen.

[Reply Card No. E6612]

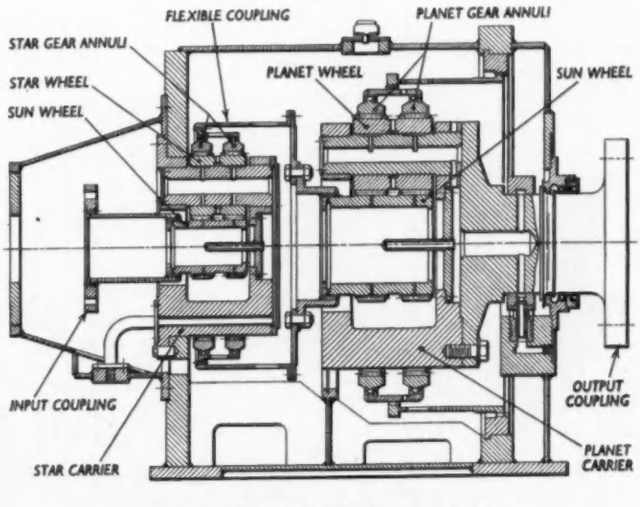
Lubrication with Molybdenum-Disulphide Dry-Film Bonded Coatings

A NOTE from K. S. Paul (Molybdenum Disulphide), Ltd., Angel Road, London, N.18, states that dry-film bonded coatings of molybdenum disulphide have shown themselves most useful for solid lubrication both during running-in and where operating conditions are particularly severe, as for example, where working parts are subjected to extreme temperature and/or pressure. It has now been found possible to increase still further the resistance of " Moly-VI-Bond " to abrasion, oxidation, and to attack by acids and alkalis, by the addition of some 2 per cent of a special composite resin which also improves the elasticity of the film, so facilitating subsequent processing of light alloys, tin plate, steel, &c.

The new " improver " is colourless, non-toxic, and free from taste or smell. In use it is simply mixed with " Moly-VI-Bond " when the mixture has a minimum shelf life of four months. Application of the bonded coating is unchanged except that hot curing is essential (for example, 1½ hours at 180 deg. Cent. or three to five minutes at 340 deg. Cent.).

[Reply Card No. E6613]

Input end of double-reduction epicylic gear for mine hoist



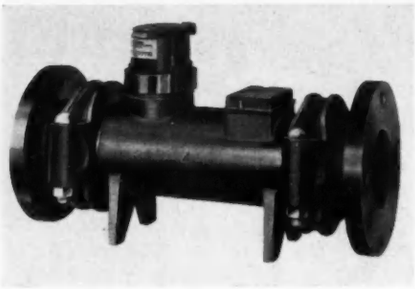
Arrangement of double-reduction epicyclic gear

SHORTER REPORTS *(Continued)*

Water Meters

WATER meters for use in any pipeline having a high flow rate and requiring minimum head loss are now being made by Parkinson Cowan Measurement, Dobcross, Oldham, Lancs, in four sizes to handle flows of from 800 to 200,000 g.p.h. Each meter is guaranteed to measure within its recommended flow range with a maximum error of ±2 per cent.

In these meters, one of which we illustrate, a



Full-flow water meter for pipelines. This meter is made in four sizes to handle flows from 800 to 200,000 g.p.m.

helical rotor mounted in plastics bearings in the body is turned at a speed directly proportional to water flow velocity. The rotary motion is transmitted to the index via reduction gears and a stuffing box. The gears and bearings are made from a plastics material which reduces the effects of friction to a minimum and resists corrosion.

Straightening vanes fitted at the meter inlet prevent turbulence which could cause inaccuracy and a regulator is provided to give fine calibration adjustment. Only two bolts have to be removed from the "Victaulic" joints used to couple a meter into a pipe line to enable the whole assembly to be removed for inspection, testing and calibration.

The meters can be used with a wide selection of the indicating and controlling devices used in industrial process control.

[Reply Card No. E6621]

Semi-Rotary Actuator

A SEMI-ROTARY, single-vane actuator now made by Dowty Hydraulic Units, Ltd., Ashchurch, Glos., has a maximum operating pressure of 1000 lb per square inch. At this pressure a starting torque of approximately 2200 lb per foot and a dynamic torque of approximately 2800 lb per foot are available. The usable angular movement is 200 deg. and external travel limiting stops are required.

Single-vane semi-rotary actuator for a maximum operating pressure of 1000 lb per square inch

In these actuators, one of which is illustrated below, provision is made for the manifold mounting of a relief valve. This valve is effective both for controlling pressure due to inertia loads, pressure fluid being discharged via the valve to the unloaded side of the unit, and for discharging pressure fluid from the pump to the return line at the travel stop positions.

The single moving vane, also its associated fixed vane, bolted and dowelled to the shaft and cylinder respectively, are sealed with continuous "D" section rubber seals in conjunction with leather anti-extrusion rings. Shaft sealing is effected by two "O" ring sets in conjunction with anti-extrusion rings at each end of the shaft; the outer sets of seals are subject only to return pressure.

[Reply Card No. E6622]

Resistance Welder Pressure Recorder

AN instrument introduced recently by A. S. Young and Co., Ltd., Woodside Lane, London, N.12, is designed to measure the pressure between the electrodes of resistance welding machines. The instrument, when used with means normally provided on the machines for controlling the setting and duration of the welding cycle, is stated to ensure full information to enable the making of satisfactory resistance welds.

The recorder, to be seen in the illustration, is

Instrument for measuring the electrode pressure exerted in resistance welders

available in two pressure ranges from zero up to 600 lb and up to 2000 lb. In use it is held between the electrode tips of the welder, resting on the bottom tip with the centre of the plunger underneath the top tip. When the tips are brought together by operation of the pedal on the machine the pressure developed is shown on the recorder dial in pounds. The pressure required is related to the tip diameter which is determined by the thickness of the metal being welded. Tables showing tip sizes and pressures for various gauges of metal can be found in B.S.S. 1140/1957.

[Reply Card No. E6623]

Portable Oxygen Analyser

THE form of magnetic susceptibility cell used in the industrial oxygen analyser manufactured by Servomex Controls, Ltd., Chemical Instrument Division, Crowborough, Sussex, for the Distillers Company has now been incorporated in the Servomex portable analyser illustrated. Applications for which it is suitable occur in gas works, steel works, boiler-houses, chemical plants, refineries, brewing and fermentation processes, dyeing, and general research work.

Battery-operated oxygen analyser incorporating magnetic susceptibility measuring cell

The DCL 101 portable analyser is a battery-operated device which can be regarded as an alternative to the Orsat apparatus for determination of oxygen anywhere in the range 0–100 per cent to an accuracy of plus or minus 0·1 per cent. As the device is linear, calibration at two points is sufficient to standardise over the whole scale. Zero is highly stable and a check using air as a test gas is sufficient for most normal uses.

The analyser may be used with static samples or with a continuously flowing sample at rates up to 150 ml per minute, the sample being filtered and cooled sufficiently to remove condensate. The measuring cell contains a very light dumb-bell shaped test body suspended by a platinum ribbon in a non-uniform magnetic field. Torque on the test body produced by the presence of oxygen in the measuring cell is balanced by passing current through a coil wound on the dumb-bell. The balance condition is observed by means of a light spot reflected on to a scale and is obtained by adjusting a calibrated source potentiometer. Read-out is taken direct from a linearly calibrated ten-turn dial. Dimensions of the instrument are 13in long, 8¼in wide and 9½ in high and the weight is 18 lb.

[Reply Card No. E6624]

Calorifiers

A RANGE of non-storage calorifiers has been introduced by Holden and Brooke, Ltd., Sirius Works, Manchester, 12, to cover the full requirements of heating installations. These calorifiers are available in two series with nineteen sizes in what is known as the "Nordon" type from which capacities up to 8,000,000 B.Th.U. can be obtained. The "Wython" calorifiers in the second series are built to B.S.S.853, and made in sixteen sizes, the maximum capacity in this case being 6,000,000 B.Th.U. The size selection of a calorifier for a given duty is facilitated by a nomogram provided in the firm's literature for the standard duties required.

Both types of the calorifiers can be assembled as horizontal or vertical units and they are designed for steam pressure limits on the primary side of 5 lb per square inch to 100 lb per square inch, the shell side maximum working pressure being 50 lb per square inch. In their construction welded mild steel plate, with cast iron steam boxes and solid drawn copper "U" tubes are used principally.

[Reply Card No. E6625]

INDUSTRIAL NEWS

Safety in Industry

This year's National Industrial Safety Conference, organised by The Royal Society for the Prevention of Accidents, will be held at Scarborough from May 12 to 14. It is expected that over 1000 delegates will be present. Because of the rising trend of accidents at work, exceptional importance is attached to this year's conference, the Royal Society says, and one of its main purposes is to improve the techniques of industrial safety officers in their struggle to reduce accidents. According to the provisional figures issued recently by the Ministry of Labour both non-fatal and fatal factory accidents showed an increase in 1960, compared with 1959. The number of non-fatal accidents rose by 15,931 to 189,404, while the number of fatal accidents increased by sixty-seven to a total of 665 in 1960.

Sir Howard Roberts, President of the Royal Society for the Prevention of Accidents, will make the opening address of the conference on Friday, May 12, at 8.30 p.m. He will also present the Sir George Earle Trophy, awarded annually for the most outstanding contribution to industrial safety during the preceding year. The award for 1960 will be made to a unit of the building industry.

The following papers will be presented at the conference: "Safety Begins in the Boardroom," Mr. G. H. Beeby, chairman of British Titan Products Company, Ltd.; "Safety Through Tidiness," Mr. C. H. Craft, director of John Laing Construction, Ltd.; "Structural Fire Protection in Factories," Mr. E. L. Bird, technical research and education officer at the Building Centre, London; "Safety with Solvents," (to be read by Mr. K. Lazenby), Mr. J. Howlett, general manager of the Hull site of the Distillers Company, Ltd., and a director of that company.

A trade exhibition of industrial safety appliances will be held in conjunction with the conference.

Industrial Relations

A new edition of the Ministry of Labour's *Industrial Relations Handbook* has been published and is available from H.M. Stationery Office, price 5s. 6d. Successive revisions of the *Handbook* have not changed its character. It remains what it was originally designed to be, the Ministry says, a manual for people for whom industrial relations are a matter of everyday practical concern.

The *Handbook* presents essential facts about the organisation of employers and employed in Great Britain. It describes how they negotiate with each other, what they negotiate about, how differences are settled, what part is played by procedures and institutions set up by statute and, more generally, indicates the ways in which relationships at the place of work may be adjusted.

The book is divided into three parts, the first of which is mainly devoted to an account of how employers and employed organise themselves. The second part of the *Handbook* describes the ways in which the Minister of Labour intervenes in industrial relations and the statutory basis for this action. The third and last part of the *Handbook* gives some information about wages, hours of work and holidays—which, the Ministry says, are the staple subject-matter of collective bargaining.

Iron and Steel

The Iron and Steel Board has stated that the production of crude steel during March was at an average of 471,000 tons a week compared with 485,300 tons a week in February and with 485,100 tons a week in March, 1960. Most of the fall in output compared with a year ago took place in North and South Wales, where the works were particularly affected by the temporary weakness in demand for sheet and tinplate. The total production of steel in the first quarter of 1961 amounted to 6,210,000 tons.

There are signs, the Board says, that the renewed activity in the motor industry is promising a revival in ordering for products such as steel sheet which have recently been adversely affected. Stock movements during the first quarter suggest that the substantial stockbuilding which took place during last year has come to an end. The cessation of stockbuilding has in the main resulted in a fall in imports of finished steel. The use of steel appears to have been maintained at last year's level.

Exports of steel during the first two months of 1961 were at an average rate of 259,000 tons a month, which was in line with the expectation of a further rise in exports above last year's improved level, the Board says, whilst imports during the first months of the year at 52,000 tons a month were well below the average rate for 1960.

Exports

In his presidential address at the annual general meeting of the Federation of British Industries last week, Sir William McFadzean claimed that 1960 would be labelled "The year of Exhortation." He expressed the strong hope that 1961 would become "The Year of Action." As an export target, he said, Britain must aim at an increase of at least 10 per cent. Sir William said he believed this could be achieved by ensuring that Britain was an extremely efficient producer of the right goods at the right price and at the right time. Too little attention, he added, was still being given to the tastes and requirements of overseas customers. Britain was still falling down on delivery and in not notifying customers quickly enough when delivery was going to be delayed.

It must be fully appreciated, Sir William went on, that there were many factors outside the control of industry which vitally affected the export performance of this country—such as the cost of products and services from the nationalised industries; transport and dock facilities; the level of Government and public authority expenditure and such like.

Sir William said that he felt most people would agree with the contention that Britain had not enough salesmen on the road. Salesmen to be really effective overseas should be able to speak languages and should know the feelings and appreciate the requirements and aspirations of the countries to which they were selling. He sometimes wondered, he added, if the virtues and status of being a scientist, a technician, a production efficiency expert, &c, have all been over-boosted for many years relative to being a salesman. Too often in this, and possibly other countries, Sir William said, the belief was held, that any "dogsbody" could go on the commercial side; how wrong this was.

Commenting on credit and credit insurance, Sir William said that Britain did not, in his opinion, compare unfavourably with other countries in credit insurance, but where there could be an improvement was in the more flexible and speedy implementation of its regulations. On credit, he added, Britain may have to be more generous in special cases.

Mr. Cyril E. Harrison, vice-chairman and managing director of the English Sewing Cotton Company, Ltd., was elected president of the Federation for the next two years.

Export Credits

Changes in the services offered by the Export Credits Guarantee Department were announced by Mr. Reginald Maudling, President of the Board of Trade, in the House of Commons, last week. The changes could be summarised under three main headings, Mr. Maudling said. First, he had approved a new scale of premiums for medium-term business, which would reduce the total premiums charged by about 25 per cent. The main benefit of these reductions, he added would be concentrated in those markets where at present the highest rates were charged. There would also be reductions in the more expensive markets.

The second heading, Mr. Maudling stated, was longer-term export finance. In the case of very large capital projects and of ocean going ships, where the return on any investment may take many years to mature, the buyer may need and expect credit going beyond five years from delivery and he could already obtain it in some foreign countries. A new system was being introduced, Mr. Maudling said, whereby the Department would guarantee loans for longer periods made by financial institutions in this country to creditworthy overseas purchasers.

Thirdly, Mr. Maudling said, in order to help small and medium sized firms with little or no experience of exporting, a new form of export credit cover was to be introduced for firms with a current export turnover of less than £10,000 a year. This would be available across the counter at all branches of the Export Credits Guarantee Department and would cover small exporters in respect of transactions with individual approved buyers, at a flat rate of premium. The cover would be available for a limited time. This simple and easily accessible facility, Mr. Maudling added, should encourage new firms to enter the export market and subsequently become customers of the Department on a normal basis.

PERSONAL AND BUSINESS

Appointments

MR. HUGH WEEKS has been appointed a director of Hadfields, Ltd.

MR. A. R. ROBERTSON has been appointed registrar of the United Steel Companies, Ltd., from April 10.

MR. GEOFFREY BARNES, A.M.I.E.E., has joined the staff of Ultra Electronics, Ltd., as an executive engineer.

MR. B. J. HARPHAM, of Collingwood Conveyor Equipment, Ltd., has been appointed managing director.

THE PLESSEY COMPANY, Ltd., announces the appointment of Dr. A. W. Henderson as chief chemist/metallurgist.

ALCAN INDUSTRIES, Ltd., has announced the election of two new directors to its board, Mr. A. A. Bruneau and Mr. R. J. Moyse.

MR. K. J. H. ADAMS has been appointed production manager of the semi-conductor division of Brush Crystal Company, Ltd.

CATCHPOLE ENGINEERING COMPANY, Ltd., announces that Mr. Gordon Avill has been appointed representative covering the north of England.

THE PLESSEY COMPANY, Ltd., announces the appointment of Mr. L. Walker, M.I.E.I., as company chief inspector for the Plessey Group of Companies.

MR. BERNARD WILLIAM LYNN, M.I.E.I., has been appointed general planning and procurement manager of the Perkins Group of companies, Peterborough.

COLONEL R. W. W. TAYLOR, managing director of Lang Pneumatic, Ltd., has been appointed vice-president of the British Compressed Air Society for the ensuing year.

ROBERT JENKINS AND CO., Ltd., states that Mr. Harold T. Jenkins has been appointed technical director and Mr. J. S. Waring has been appointed production director.

MR. H. E. COX, M.I.E.E., has been appointed director of manufacture, Associated Electrical Industries (Rugby), Ltd., following the recent retirement of Mr. H. L. Satchell.

MR. O. A. OVER, A.M.I.C.E., formerly chief assistant engineer of Sheffield Corporation Waterworks, has been appointed deputy county water engineer and manager, Anglesey.

APPLEBY-FRODINGHAM STEEL COMPANY, a branch of the United Steel Companies, Ltd., states that Mr. E. A. Atkin, formerly assistant chief engineer, became deputy chief engineer on April 1.

BRYCE ELECTRIC CONSTRUCTION COMPANY, Ltd., announces that Mr. H. R. Lowday has been appointed production director and Mr. J. O. M. Palmer, A.M.I.E.E., has been appointed technical director.

THE HOLSET ENGINEERING COMPANY, Ltd., has announced that Mr. R. B. Hesselden, A.M.I.Mech.E., has been appointed a director and Mr. R. Barr, A.M.I.Mech.E., has been appointed works manager.

HAWKER SIDDELEY INDUSTRIES, Ltd., states that Dr. L. R. Blake, A.M.I.E.E., has been appointed to the new post of director of engineering at Brush Electrical Engineering Company, Ltd., and has joined the Board as an executive director.

HACKBRIDGE CABLE COMPANY, Ltd., states that Mr. W. A. E. Painting, M.I.E.E., has been appointed technical director and Mr. R. H. Hodgson has been appointed production director. Mr. J. F. Ransom has been appointed sales manager.

BURTONWOOD ENGINEERING COMPANY, Ltd., announces that a new post of works director has been created which is to be filled by Brigadier C. J. Tobin. Brigadier Tobin has also been appointed to the board of directors with effect from May 15.

MR. E. G. LAMB, A.M.I.E.E., senior lecturer at the Royal Technical College, Salford, has been appointed head of the department of electrical engineering at the City of Liverpool College of Technology, in succession to Mr. J. E. Macfarlane who has retired.

THE PRESS AND SHEAR MACHINERY COMPANY, Ltd., announces that Mr. H. Baldwin has now been appointed the firm's midlands area representative in the office at 1975, Kingsbury Road, Erdington-Birmingham, 24, (telephone Castle Bromwich 3781/2.)

THE NATIONAL COAL BOARD has appointed Mr. Cecil Yowe Peake, at present production manager, No. 5 Area, East Midlands Division, to be general manager of the No. 6 (North Barnsley) Area of the North Eastern Division. He is expected to assume the post on May 1.

MR. E. L. MORGAN, formerly works metallurgist, has been appointed chief metallurgist of Workington Iron and Steel Company, a branch of the United Steel Companies, Ltd. Mr. A. G. Hock, formerly research manager, has been appointed metallurgical consultant at Workington.

THE LONDON SHAFTING AND PULLEY COMPANY, Ltd., states that Mr. G. C. Hart has taken over as sales manager (home) from Mr. F. N. Honey who has been appointed general manager. Mr. E. J. Metcalfe will shortly take up the appointment of western area representative based in Exeter.

MR. K. H. L. COOPER, at present commercial director of the Billingham Division of Imperial Chemical Industries, Ltd., is to be commercial managing director in succession to Mr. J. W. Kerr, who is retiring on May 31. Mr. R. W. Pennock has been appointed a Billingham Division director from June 1 when he will succeed Mr. Cooper as commercial director.

IMPERIAL CHEMICAL INDUSTRIES, Ltd., Nobel Division, announces that Dr. James Craik, chairman of the Division since 1955, has retired and has been succeeded by Dr. John M. Holm. Dr. Holm has been succeeded as a joint managing director by Dr. A. D. Lees, whose position as production director has been taken over by Dr. J. Bell, the Division's engineering and technical director. Mr. J. A. Loft-house has been appointed to the board and succeeds Dr. Bell. Dr. J. S. Flanders has been appointed a director and follows Mr. A. D. McLean as the Division's home sales control and technical service director. Mr. McLean has joined I.C.I.'s Heavy Organic Chemicals Division as commercial director.

Business Announcements

ELLIOTT-AUTOMATION, Ltd., 34, Portland Place, London, W.1, announces that it has formed a new subsidiary company, A.B. Elliott-Automation in Sweden.

FERRANTI, Ltd., Hollinwood, Lancs, has set up a northern computing service in Manchester which is available for industrial, scientific and commercial calculations.

CHRISTY AND NORRIS, Ltd., Chelmsford, states that Mr. J. F. Myall, works director, and Mr. F. H. Mills, technical sales director, have retired. Their combined service amounted to 102 years.

AVELEY ELECTRIC, Ltd., Ayron Road, Aveley Industrial Estate, South Ockendon, Essex, has been appointed sole United Kingdom agent for the measuring, testing and control instruments made by the Bach-Simpson Company, of Canada.

MR. ARTHUR CLIVE LANE, A.M.I.E.E., section leader and design engineer, a.c. commutator motors, medium electrical machine engineering department, Associated Electrical Industries, Ltd., heavy plant division, retired on April 14, after thirty-eight years' service.

MR. J. V. KLEIN, joint managing director of the Compoflex group of companies is at present visiting Finland, Sweden, Denmark, Germany, Holland Switzerland and Italy, to liaise with the group's Continental agents. He returns to the United Kingdom on May 15.

THE PLESSEY Company, Ltd., Ilford, Essex, announces that a licence agreement has been concluded with Guldner-Motoren-Werke, a member of the Linde Group of Companies in Germany, to manufacture "Hydro-Stabil" equipment for sale in the United Kingdom and throughout the British Commonwealth.

COLLOIDAL GRAPHITE, Ltd., Sheaf Island Works, Pond Hill, Sheffield, 1, states that on May 1 the Company will become Susgra, Ltd. The company's sales and manufacturing policies will be unchanged and will continue to be under the direction of Mr. A. A. Simons who has been appointed to the board of Susgra, Ltd.

THE GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, London, W.C.2, and A.E.I. LAMP AND LIGHTING COMPANY, Ltd., have agreed to form a joint company for the manufacture and sale of molybdenum, tungsten and other metal products associated with the electric lamp and radio valve industries.

THE MORGAN CRUCIBLE COMPANY, Ltd., ceased to trade on April 3 and became a holding company. From that date, its responsibilities for production, trading, research and development have been assumed by the following five new wholly owned subsidiaries: Morganite Carbon, Ltd., Battersea, S.W.11, carbon products (electrical), carbon products (mechanical), sintered bearings ("Reservoil"); Morganite Crucible, Ltd., Norton, Worcester, crucibles ("Super"), crucibles ("Suprex"), furnace and foundry accessories; Morganite Electroheat, Ltd., Wandsworth, S.W.18, furnace elements ("Crucilite"); Morganite Research and Development, Ltd., Battersea, S.W.11, research and development; Morganite Exports, Ltd., Battersea, S.W.11, export.

Contracts

THE HEAVY PLANT DIVISION OF ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., has received an order worth nearly £1,000,000 for electrical equipment for four rolling mills to be installed at the English Steel Corporation's new Tinsley Park Works, Sheffield. The equipment will include two 3500 h.p.d.c. motors for driving a 42in blooming and slabbing mill, two motors (one of 4000 h.p. and the other of 5000 h.p.) for two 32in billet mills and a bar mill drive consisting of a 2000 h.p., a 1000 h.p., five 450 h.p. and two 350 h.p. motors. A.E.I. will also supply the power and control equipment for the motors.

W. H. ALLEN SONS AND CO., Ltd., Bedford, announces that it has received an order from Thames Board Mills, Ltd., of Purfleet, Essex, for the supply of one 10·5MW pass-out back-pressure turbo-alternator set. The machine will be designed to operate with steam at 600 lb per square inch gauge and 740 deg. Fah., passing out up to 120,000 lb per hour of process steam at 55 lb per square inch gauge with an equal quantity available at an exhaust pressure of 21 lb per square inch gauge under conditions of reduced pass-out flow. The Allen turbine will run at 3000 r.p.m. and drive directly, an English Electric water-cooled alternator supplying power in parallel with existing machinery for an 11kV, 50 cycle supply at 0·8 power factor. The plant is to supply power and process steam for the expansion programme of Thames Board Mills, Ltd., who, in in the first phase, are installing a new packaging board machine which will initially produce 80,000 tons per year.

PYE, Ltd., has received a contract from the British Broadcasting Corporation for five mobile television control rooms for outside broadcasts. All will have four Pye 4½in image orthicon camera channels and will be capable of operation with up to 2000ft of camera cable. A new feature of the vision mixer, which has been developed by the B.B.C., is a detachable control panel which can be operated when required up to 300ft from the main equipment. These control rooms will have a body width of 8ft and an overall length of 25ft and each will be built on a 7-ton commercial vehicle chassis. The production area, which is air-conditioned, will be separated from the equipment compartment. Power consumption and heat dissipation from the equipment will be minimised by the use of transistors instead of valves wherever possible, notably in the sound equipment, pulse generators and inter-communication installation, and also in the vision mixer.

Death

WE record with regret the death of Captain A. E. Penn who died on April 1 at the age of ninety-three. Captain Penn was educated at the Wandsworth Road Commercial School, Clapham. He was apprenticed in 1882 at the Gulcher Electric Light and Power Company, Battersea, and served the company for ten years. In 1901 he was appointed chief engineer to C. Bayer and Co., and in 1905 he joined the Tribune Newspaper Company, Ltd., as chief mechanical and electrical engineer. From 1913 Captain Penn was the London engineering representative of Jenkins Bros., Ltd. He was elected a member of the Association of Engineers-in-Charge in 1907, and was a Councillor from 1908-9. From 1910 to 1912 Captain Penn was chairman of the Association, and in 1912, he was elected honorary secretary, and continued in this office until his death. Captain Penn was responsible for the detailed work involved in the incorporation of the Association as an Institution. He was also editor of the Institution's *Transactions*.

Miscellanea

HIGH SUPERSONIC WIND TUNNEL.—It has been drawn to our attention that it was not explicitly stated in the above-named article on page 450 *ante* that the Royal Aircraft Establishment is a Ministry of Aviation establishment and that responsibility for engineering works is vested in H.M. Ministry of Works.

CONTINENTAL AFFAIRS

by Our Continental Editor

Jubilee of the Lötschberg Tunnel

FIFTY years ago, on March 31, 1911, occurred the break-through of the Lötschberg Tunnel at a distance of 7237m from the south adit and 7368m from the north adit (the mileages quoted here take into account the artificial lengthening by about 70m necessitated by avalanche dangers, as well as correcting a survey error made at the time of the opening).

The decision to complete the 58km of railway from Frutigen to Brig—the line from Spiez to Frutigen had been in operation since 1901—was taken by the Canton of Berne in June, 1906, a few weeks after the opening of the Simplon Tunnel. There followed the setting-up of the Bern–Lötschberg–Simplon Alpine Railway Company (BLS) which, in August of the same year, awarded the contract to the French consortium Entreprise Générale du chemin de fer des Alpes Bernoises Berne–Loetschberg–Simplon (EGL). The total contract sum amounted to Sfr. 87 million of which the main tunnel accounted for Sfr. 50 million. It was eventually completed as a double-track tunnel in sixty-six months, at a cost of Sfr. 52 million, or Sfr. 3600 per metre. This compares with over Sfr. 5400 per metre for the first of the great Alpine tunnels, the Mont-Cenis (1860–71), and Sfr. 3900 per metre for the Gotthard (1872–81), the great predecessor and competittor of the Lötschberg–Simplon route. Together with the reduction in building time—the Gotthard, of similar length and profile, took 111 months to complete—figures such as these vividly illustrate the progress which had been achieved in the intervening years. The First Simplon Tunnel (1898–1906) shows up even more favourably. The construction of the Lötschberg tunnel was marked by two major disasters. Early in 1908, an avalanche killed eleven men in their billet at Goppenstein, and on July 24 of the same year there occurred a catastrophic flooding in the north workings which within minutes inundated some 1500m of tunnel with 6000 cubic metres of sand and gravel, and engulfed the entire team of twenty-five people at the workface. Another man was drowned trying to make his escape. Only one body could be recovered, and after vain attempts to clear the tunnel, it had to be sealed approximately 1430m from the adit, and over 1200m abandoned. The flood disaster was caused by the tunnel, which had been projected in a straight line, emerging at Km. 2·675 from the solid rock into the water-bearing alluvium of the Gastern Valley. The geological report on which the project had been based had, on insufficient evidence, assumed the alluvium to be no deeper than 100m, so that there should have been at least 100m of bedrock between the loose water-bearing strata and the tunnel roof. Unfortunately, no trial borings had been carried out, and minor inflows of muddy water just before the disaster had been disregarded, as it was thought that the danger zone had already been traversed. To judge by the steepness of the valley flanks, however, the alluvium may well extend as deeply as 300m to 450m beneath the surface. Eventually the work, which had been stopped after the disaster, was resumed in February, 1909, over six months later. It was decided to bypass the valley by taking the tunnel 1656m farther to the east, starting at Kms. 1·203 in the north and 10·208 in the south. This added 800m to the length.

The north and south adits lie respectively 1196·74m and 1216·29m above sea level, and the highest point at Km. 7·080, 1239·54m above sea level. The errors at the point of break-through amounted to only 410mm in length, 257mm in direction, and 102mm in level, a testimony to the high quality of the surveying work.

In the construction of the tunnel, electricity was used exclusively for the first time to provide compressed air for the drilling as well as for driving the ventilating fans. Installed power was up to 2000 h.p. on each side.

The mine cars at first were drawn by horses, later compressed air locomotives were used, except in the south section where horse traction continued between the face and the lined portion, and where also some steam locomotives were employed.

The tunnel was driven at first in a pilot section at the bottom followed by a second tunnel at the top of the full section, or alternatively by slitting the section from the bottom to the top. The break-out was then widened at the top and carried down on both flanks, the section being supported by heavy timbers. Only after the full section—effectively about 57·6 square metres—had been excavated over a certain length, was the lining commenced. The abutments were continuous over long distances while the vault was in the form of abutting arches 6m to 8m long. Generally, the lining thickness was 0·4m and only occasionally 0·6m to 0·8m. A total of 1768m where compression in the rock was not felt was lined with prefabricated concrete blocks. Over 2691m of tunnel it was also necessary to line the bottom, but this could be left until after completion of the vault. On account of its cheapness a mixture of Portland cement and stone dust was employed. While samples of the resulting concrete and mortar were satisfactory at the time, it has stood up badly to water and frost, resulting in continuing heavy expense for re-pointing and other maintenance.

Temperatures of the rock reached up to 34 deg. Cent. (Gotthard 30·7 deg. Cent.; Simplon 55·4 deg. Cent.). Progress with the pilot tunnel of 6·2 square metre cross section averaged 7·26m per day in the north section and 5·08m per day in the south, or a total of 12·34m per day. This compared with 6·2m per day on the Gotthard and 10·41m per day on the Simplon ; or 4·75m per day on the Gotthard and 11·76m per day on the Simplon on the basis of an equal tunnel section and equal number of drills simultaneously in operation. The improvement was mostly due to the better drills which had become available, and to the fact that drilling was commenced before mucking-out had been completed. Consumption of explosive amounted to 3·9 kg per cubic metre of dynamite (93 per cent nitroglycerine) for the pilot tunnel, and 0·8 kg per cubic metre of Westphalit and Telsit for the full section. The first electric locomotive passed through the Lötschberg Tunnel on June 3, 1913.

"Nora" Research Agreement

An agreement has been signed between the United States, Norway and the International Atomic Energy Agency (I.A.E.A.) concerning the joint I.A.E.A.–Norwegian programme in reactor physics. This project aims at obtaining precise and widely applicable reactor physics data on cores with mixed and variable lattices moderated by light water, heavy water, and mixed heavy and light water. Norway is making available its critical assembly "Nora," due to become critical in May, and two of the cores to be used in this work are also being supplied by Norway ; one of these consists of natural uranium and the other of slightly enriched uranium. The supply agreement with the United States will make available a third fuel core enriched to 3 per cent in the radioisotope U235. This core was originally used in development work for the nuclear merchant ship "Savannah" and contains approximately 42 kg of U235. This is the first lease of special nuclear material through the Agency to one of its Member States.

International Handicrafts and Trade Fair

This year's International Handicrafts and Trade Fair will be held at Munich during the period May 31 to June 11. The Fair, foreign participation in which last year amounted to more than 40 per cent, will comprise twenty-three halls covering an area of 52,000 square metres, on which exhibitors from over twenty different countries will show their goods. Besides the various branches of handicrafts, the supplying industries will be represented with special machines including plastic and precision machinery, building equipment, workshop supplies, and tools. Further information may be obtained from the Secretariat of the Fair, Munich 12, Theresienhöhe 14.

Rolling Mill for ARBED

A continuous billet mill built by Schloemann Aktiengesellschaft, Düsseldorf, for the ARBED works at Esch, Luxembourg, has been put into operation. It is designed for the production of 60mm by 60mm, and 80mm by 80mm billets. As the draughting schedule is the same for both billet sizes, all the train's eight stands can be powered by a single motor. With the aid of electrical and hydraulic equipment each stand can be shifted to a fixed pass line. All stands are provided with hydraulic roll-changing rigs, so that down times are kept to a minimum.

A similar eight-stand continuous billet mill is being built by Schloemann for the ARBED works at Burbach, near Saarbrücken. This plant is intended for rolling 75mm by 75mm or 80mm by 80mm billets respectively. It is scheduled for commissioning at the end of 1962.

Radioactivity in the Sea

Research on the effects of radioactivity in the sea is to be undertaken by the International Atomic Energy Agency under an agreement recently concluded between the Agency, the Government of Monaco, and the Oceanographic Institute in Monaco. The work will be undertaken at the Scientific Centre of the Government of Monaco, and will seek to elucidate the problem of possible pollution of the sea through the deposition of radioactive materials. Studies extending over the next three years are to be carried out regarding the movement of water and marine organisms and the deposition of organic and inorganic matter, the distribution in marine organisms of radioactive materials already existing or introduced artificially, and the effects on marine life of radioactive materials at various concentration levels.

THE AMERICAN SCENE

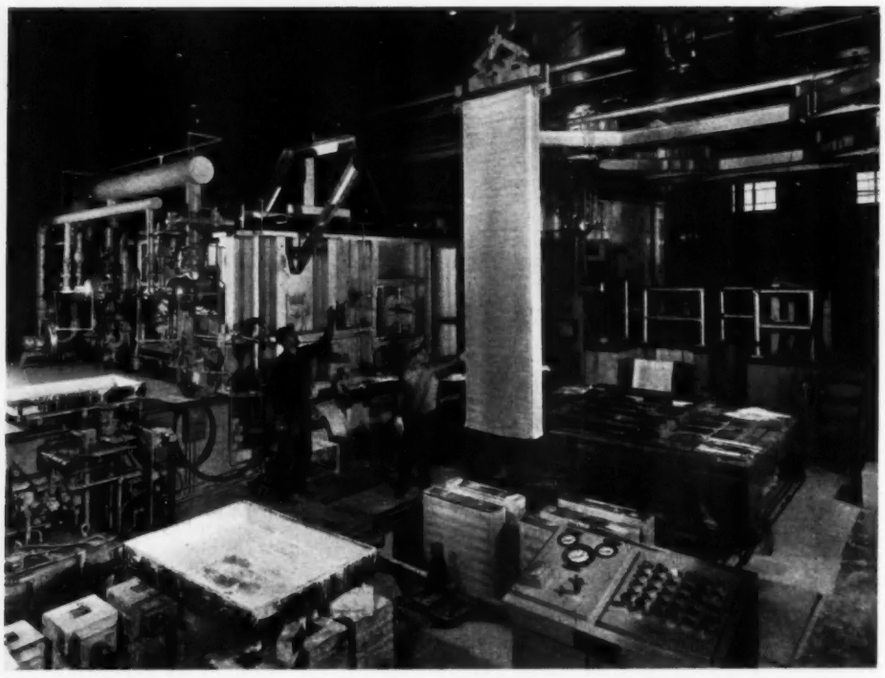
By Our American Editor

Aluminium Alloy Slab Casting and Sawing Installation

AFTER an initial " breaking-in " period, a large slab casting and sawing installation is now in full production at the aluminium sheet rolling mill of the Quaker State Metals Company, at Lancaster, Pennsylvania. The semi-continuous casting station (illustrated) and the circular slab saw with auxiliary conveying equipment were supplied by the Loma Machine Manufacturing Company of New York. Capable of producing six 7½in by 52in by 144in aluminium alloy slabs simultaneously, the casting machine turns out all the ingots required for the processing of sheet, strip and coil. From a quality point of view these continuously cast slabs are greatly superior to those formerly cast in conventional book moulds, particularly since one of the methods by which the grain size of the cast material can be controlled is by regulating the casting speed.

For sub-dividing and trimming the 12ft long sheet ingots, Quaker State has installed a Loma high-speed circular saw capable of cutting through a 12in by 52in aluminium alloy section in about one minute. The sawing machine is of the overhead sliding carriage design and employs a 48in diameter blade cutting at a speed of 6000ft per minute. The sawing installation includes a slab charging conveyor, an automatic length stop, a slab discharge conveyor and a chip removal unit. This fully mechanised stock handling equipment combined with the extremely fast feed movement of the saw allows a single operator to run the entire installation at a very high production rate.

The Quaker State Metals Company is one of the principal American independent aluminium rolling mills and fabricators. It produces aluminium sheet, coil and tubing for sale to fabricators of sheet metal products and also manufactures such building products as roofing materials, siding, gutters and down spouts, acoustical ceiling panels and curtain wall partitions.

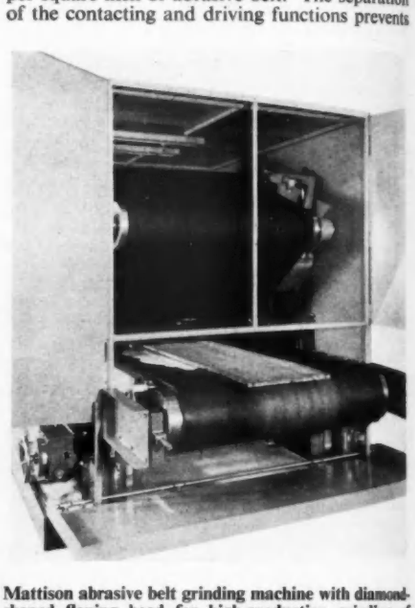


Loma semi-continuous casting installation for aluminium alloy slabs at the Quaker State Metals Company

Abrasive Belt Grinding Machine with Feed Conveyor

The Mattison Machine Works, of Rockford, Illinois, has introduced an abrasive belt grinding machine with a diamond-shaped head that " flexes " the belt as it drives. The machine is now being used in the American aircraft industry for the high-production grinding of honeycomb materials, holding tolerances as close as plus or minus 0·001in. Because of this unusual accuracy, the machine is ideally suited for finishing honeycomb sheet stock, small parts, such as motor laminations, and similar high-production flat work requiring critical thickness tolerances. Positive grain penetration is achieved through a combination of high horsepower on the belt drive and the diamond head design. Four rollers in the diamond-shaped head continuously " flex " the abrasive belt to keep it clean, cool and free-cutting.

Each of the four rollers has a special function. One roll aligns the belt, one drives it, and another supplies grinding pressure. The fourth is an idler that provides additional belt flexing to prevent loading and to increase stock removal per square inch of abrasive belt. The separation of the contacting and driving functions prevents transfer of motor pulsations to the work, thus producing fine finishes. The use of four rolls avoids the " wrapping " of the belt on the contact roll. The resultant flat angle of attack permits the belt to conform more closely to the uneven surfaces of the sheet. This produces a superior scratch pattern and high finishes on sheet stock or parts.



Mattison abrasive belt grinding machine with diamond-shaped flexing head for high-production grinding of honeycomb material

The versatile grinder accommodates 36in, 48in, 60in or 72in belts, making it possible to grind large sheets or multiple small pieceparts in one or more passes, depending on stock removal. Small parts of any size may be ground because the work is held on a rubber conveyor supported by rollers up to the contact area. There is no pitch limitation as is the case when work is fed into a machine using pinch rolls. The conveyor bed is counter-balanced at each corner by air cylinders, and is fed up into the contact roll by six precision screws. The actuation of the screws is precisely synchronised from a common drive, ensuring absolute parallelism in both directions. The rapid traverse of the bed up and down may be controlled by pushbutton or manual handwheel. Automatic upfeed increments of from 0·0002in to 0·0005in per impulse are available to compensate for belt wear or partpiece size. The gauging and depth setting operations are manual. A variable speed conveyor drive provides a minimum speed of 6ft per minute and a maximum of 60ft per minute. The variable speed head drive is provided with speed changes best suited to the material, as determined by extensive belt life tests at the builder's works.

BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

RAILWAY SIGNALLING

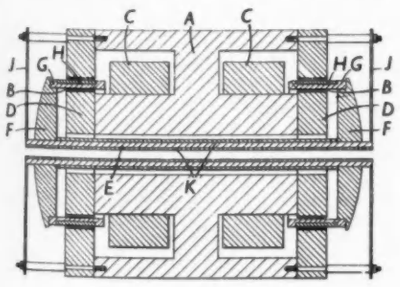
864,030. June 26, 1957.—Railway Route-Setting Apparatus, Siemens and Halske Aktiengesellschaft, Berlin and Munich, Germany.

The internal arrangement of a railway route-setting signalling system constitutes a combination of standard elements connected together to correspond to the track plan. However, owing to the relations between adjacent elements of the route setting apparatus it is necessary to provide between the associated relay groups not only numerous connections, but a correspondingly large number of contacts in these connecting lines, which contacts are subject to wear and are consequently more susceptible to breakdown than any of the other parts of the internal arrangement. The present invention proceeds from the consideration that such breakdowns can be reduced by the use of electronic circuit elements, such as are employed, for example, in modern computing installations. According to the invention a railway route-setting apparatus, comprises a magnetic storage device and an electronic computer, the magnetic storage device being adapted to store signal combinations associated with setting orders for routes, points, and signals and indications of the actual state of the route elements; and the electronic computer being adapted to compare a signal combination selected by an action on the part of an operator with the magnetically stored indication of the "actual" state of the route elements forming that combination, and, on finding a difference, to act on control arrangements for the route elements concerned so that the required state of the route elements is established. By reason of the high speed of operation of electronic computers, it is possible to employ a rapidly rotating magnetic drum on which the indications of the actual state of all the route elements are registered in binary form, i.e. as remanent positive or negative magnetisation, in one or more magnetisable tracks, while the setting orders of the required state are registered in other tracks. The programme for the setting orders may be continuously stored in the drum. Action on the part of the operator then merely results in the corresponding programme line being selected and the reading coil of this line being connected to the computer. Alternatively, it is possible for the selected indication combination, for example for a route setting order, to be transmitted to the drum store by a writing coil only when action is taken by the operator, and for it to be erased after the release of the route. The combination is transmitted to the drum from another storage device such as a magnetic core memory matrix. In this case, the number of magnetisable tracks required and the number of coils required for writing and reading are smaller.—*March* 29, 1961.

ELECTRICAL ENGINEERING

863,209. June 2, 1956.—Vibration-Generating Electric Motors, Electric and Musical Industries, Ltd., Blyth Road, Hayes, Middlesex. (*Inventor: John George Haynes.*)

With a known form of vibration generator it is found that at a certain frequency an undesirable resonance occurs and it is the object of the present invention to provide an improved arrangement with a view to reducing this resonance. The vibration-generating motor shown in the drawing comprises



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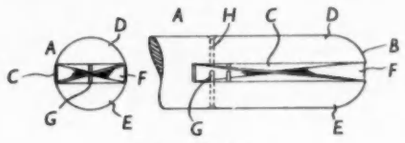
a stator in the form of a cylindrical body *A* which may be magnetised to form a permanent magnet but which, preferably, forms the yoke of an electromagnet as shown. A magnetic field can be set up in the annular air gaps *B* by energising the exciting coils *C*. Passing through a central bore in the body and through the central apertures in the inner pole pieces *D* is a tubular shaft *E* which is formed of a non-magnetic material such as aluminium alloy. Each end of the shaft carries an annular support *F* to the periphery of which is attached a sleeve *G* which may be made of electrically non-conducting material such as that known by the Registered Trade Mark "Bakelite" loaded with nylon and which projects into one of the annular gaps. Sleeves *G* constitute coil formers and each is provided with a coil *H* arranged in an annular recess in the outer surface of the sleeve. The shaft *E* is supported at each end by flexible diaphragms *J*. When the electromagnet is excited and an alternating current of suitable frequency is passed through the coils *H*, the latter and the shaft are caused to vibrate. In order to reduce undesired resonance the internal or external surface of the tubular shaft carries a solid layer *K* of rubber or other suitable material having high internal damping. Preferably both the internal and external surfaces carry such layers, each being approximately 3/16in thick.—*March* 22, 1961.

863,213. June 12, 1957.—Electric Contact Members, N.V. Fabriek van Electrische Apparaten Voorheen F. Hazemeijer and Co., 61, Tuindorpstraat, Hengelo, Province of Overijssel, the Netherlands.

This invention relates to an electric contact member, consisting at least for part of its length of two or more parallel parts, between which a member of resilient material is fitted. In general, a contact member of this type, engages against or within a co-operating contact and exerts pressure thereon. A familiar example of such an electrical connection is that formed between a plug and a socket. In the electric contact member according to the present invention, an elongated member of resilient material is in a state of torsional deformation whereby it will exert a spring force tending to separate the parts of the member. By employing a torsion member in this way, better use is made of the resilient material than is the case with a bowed or corrugated leaf spring or with a set of small helical springs. The drawings show an end elevation and a side elevation of a contact pin fitted with a torsion member. A



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cylindrical contact pin *A*, which is rounded at the end *B* to facilitate its insertion into the co-operating socket contact member, is provided at this end with a saw cut *C* extending symmetrically along the pin for part of its length, thus forming two parallel pin halves *D* and *E*. Fitted into this saw cut, in order to increase its contact pressure, is a torsion member *F* of resilient material in the form of a rectangular leaf spring to which a natural twist has been imparted through a small angle, the whole length of the torsion member being accommodated within the saw cut. The thickness of the torsion member is in practice only slightly less than the width of the saw cut. Owing to its natural twist, the torsion member is subjected to the same degree of torsion over its whole length and rests with its four corners in engagement with the inside surfaces of the saw cut, exerting a pressure tending to separate the two pin halves from one another. The torsion member is held in place in the saw cut by means of a number of small pins *G*, inserted in holes *H* drilled through the contact pin at right angles to the surfaces of the saw cut, the ends of the pins being slightly riveted after insertion. An alternative pin construction and examples of the principle applied to a knife switch are included in the specification.—*March* 22, 1961.

TELECOMMUNICATIONS

863,397. January 5, 1959.—Demodulators, The Wayne Kerr Laboratories Ltd., and John Mildwater, both of Roebuck Road, Chessington, Surrey.

This invention relates to demodulators for demodulating an amplitude-modulated carrier wave, and makes use of a Zener diode. Such a diode has a relatively low forward impedance and a very high backward impedance, provided, in the latter case, the applied voltage does not exceed some particular value. When the inverse voltage exceeds this value the backward impedance falls to an extremely low value, commonly of the order of a few ohms. This change in backward impedance is known as the Zener effect and the point at which the change in impedance occurs as the "break point." According to this invention, a demodulator comprises a Zener diode with biasing means for maintaining it at the break point, means for applying the signal to be demodulated to the diode, and an output circuit in shunt across the diode, which circuit includes a filter for removing the carrier frequency. In conventional types of diode demodulators having a load impedance connected in series with the diode, the load impedance has to be much greater in magnitude than the combined impedance of the source and diode. Stray capacitance across such a high load impedance gives distortion in the output particularly at high depths of modulation. With the arrangement of the present invention on the other hand the impedance of the diode in the conductive state is almost negligible. Since the diode is biased to be at the break point it will conduct during each half cycle of the carrier frequency so giving a unidirectional output. The filter removes the carrier frequency and hence the output from the filter will reproduce the required modulation with, for a sinusoidal carrier, an overall average amplitude of $1/\pi$ of the peak amplitude.—*March* 22, 1961.

FURNACES

862,991. December 16, 1958.—Rotary Hearth Heating Furnaces, Salem-Brosius S. A. Holding Avenue de L'Arsenal 16, Luxembourg. (*Inventor: Alan D. Dauch.*)

This invention relates to rotary hearth furnaces for heating billets, slabs &c., for hot working operations. Normally in these furnaces the charging and the discharging openings are close together and each portion of the hearth moves first past the discharging opening and the charging opening. Thus, the work to be heated traverses somewhat less than 360 deg. of the circumference of the annular furnace chamber from the charging opening to the discharging opening. It is important that the temperature in the furnace be substantially uniform transversely of the hearth. Various expedients have been tried to ensure this uniformity, but none is considered entirely successful. The gases tend to flow along the inside wall of the chamber so that there is a tendency for the temperature at the inside portion of the hearth to be higher than that at the outside. The furnace illustrated in the specification has an integral part extending across the chamber and down from the underside of the roof toward the rotary hearth. This part has mounted in it a transverse series of burners adapted to fire longitudinally into the chamber in a generally horizontal direction parallel with the surface of the hearth. The disposition of the burners ensures that, with the burners on minimum, normal or maximum firing rate, hot gases are liberated over the full width of the hearth. Individual burners may be fired at a different rate, or others may be turned off at times. The transverse series of burners firing longitudinally into the latter may be augmented by transverse burners firing into the chamber in conventional manner. It is preferred to provide such transverse burners at the soaking zone immediately preceding the discharge opening. For optimum results, the roof of the chamber may have at circumferentially spaced intervals integral parts directed down from the roof toward the hearth as described, each of these parts having a transverse series of burners adapted to fire longitudinally and substantially horizontally into the chamber.—*March* 15, 1961.

ELECTRIC TRACTION

864,005. December 16, 1958.—Pantographs, Etablissements L. Faiveley, 93, rue du docteur Bauer, Saint-Ouen, France.

Locomotive pantographs at the present time are adapted to the suspended overhead cable under which they are to travel. On multi-system locomotives, for working on networks with different voltages and forms of current, it is necessary to provide as many current-collecting devices as there are kinds of suspended overhead cable, since the pressure of the bows on the line is different according to whether the suspended cable is heavy or light, or whether the current intensities are high or low.

This invention accordingly has the object of providing means under remote control for permitting a locomotive pantograph to be adapted instantaneously to the characteristics of different overhead cables. The specification describes and illustrates how the mechanism of a pantograph of known form can be modified to meet these requirements. For this purpose the normal pantograph springs are no longer fixed to the frame at one end, but to a centrally pivoted bar to which a control rod is articulated. This rod is linked to a pivoted lever which has its opposite end connected through an insulator to the piston in a compressed air cylinder. By this means the lever can be moved by remote control to alternative positions, determined by stops, so that the tension of the springs is varied to suit light or heavy overhead wires.—*March* 29, 1961.

Catalogues and Brochures

BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION, Euston Street, London, N.W.1.—Development Report No. 64, entitled "Plating Zinc Alloy Die Castings—An Atlas of Process Defects." Preparation of die castings for plating, and the plating process itself require greater care with zinc alloy castings than with other materials because of the nature of the alloy and the complexity of shapes which can be produced. This "atlas" of defects describes the more important troubles possible and suggests means of eliminating them. The defects are illustrated at about ×8 magnification.

STEEL CASTINGS DEVELOPMENT COMMITTEE, BRITISH STEEL FOUNDERS' ASSOCIATION, 13, Broomgrove Road, Sheffield, 10.—Five data sheets on steel castings, the first of a series prepared by the Steel Castings Development Committee, which is a joint organisation of the British Steel Founders' Association and the British Steel Castings Research Association. The subjects covered range from the low-temperature properties of plain carbon steel castings to fatigue properties of plain carbon and low-alloy cast steels. Further data sheets will be issued from time to time, and a loose-leaf binder is available.

THE UNITED STEEL COMPANIES, Ltd., The Mount, Broomhill, Sheffield, 10.—Brochure entitled "This is United Steel," giving an outline history of United Steel and its constituent companies. Financial, technical and commercial details are given, and the plant and products of each of the operating companies are described briefly. The brochure concludes with a note on research, works services, labour relations and personnel services, labour relations and personnel services. Good use is made of black and white and colour illustrations, and the brochure is a comprehensive guide to the complete United Steel organisation, its products and its activities generally.

FERODO, Ltd., Chapel-en-le-Frith, Stockport.—Illustrated catalogue presenting up-to-date information on Ferodo friction materials and belts for engineering equipment, including tractors, earth moving machinery, road making plant, cranes, hoists, winches, drilling equipment, factory transport vehicles and stationary industrial plant. Details of bands are included in the Ferodo excavator band replacement service. In this new edition the data have been separated from the price list, the data section giving full details of each type of brake lining, clutch lining and belt, together with the recommended Ferodo material.

CLIMAX MOLYBDENUM COMPANY OF EUROPE, Ltd., 2, Cavendish Place, London, W.I.—Illustrated brochure of eighty pages, entitled "Three Keys to Satisfaction." This is a new and revised edition of a former publication of the same title—prepared in response to a demand for its reappearance. The "three keys" of the title are good design principles, proper election of steel according to duty, and correct treatment of the steel. There are three sections of the brochure, dealing in turn with the subjects named, and detailing such things as avoidance of stress raisers, choice of grade and type of steel, and various forms of treatment which can affect its properties, such as cold working, hardening, nitriding and welding.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ANTIQUARIAN HOROLOGICAL SOCIETY

Sat., April 22.—Chartered Auctioneers' and Estate Agents' Institute, Regent House, St. Philip's Place, Colmore Row, Birmingham, 3, "Escapements for Clocks," W. J. Gazeley; "A Tour of My Own Collection," Bernard Hawkins, and "The Works of Peter Litherland of Liverpool," R. Vaudrey Mercer, 2 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

To-day, April 21.—SOUTH MIDLANDS SECTION: North Gloucestershire Technical College, Cheltenham, Annual General Meeting, and "The Mesa Transistor and its H.F. Applications," D. H. Mehrtens, 7 p.m.

Wed., April 26.—London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Symposium on "Electronic Counting Techniques," 6 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., April 26.—SOUTHAMPTON SECTION: Technical College, St. Mary's Street, Southampton, Joint meeting with the Southampton Metallurgical Society, Annual General Meeting, and "Foundry Sands and Moulding Materials," W. B. Parkes, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Tues., April 25.—Memorial Building, 76, Mark Lane, London, E.C.3, Presidential Address by The Rt. Hon. The Viscount Simon, and Annual General Meeting, 5.30 p.m.

Thurs., April 27.—WEST MIDLANDS SECTION: Engineering Centre, Birmingham, "The History and Development of Air and Gas Compressing Plants," M. J. Waldon, 7 p.m.

INSTITUTE OF METALS

To-day, April 21.—WEST OF ENGLAND METALLURGICAL SOCIETY: College of Technology, Ashley Down, Bristol, 7, "Temperature Measurement," J. A. Hall, 7.30 p.m.

INSTITUTE OF NAVIGATION

To-day, April 21.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Marine Radar Presentation," S. R. Parsons and F. J. Wylie, 5.15 p.m.

INSTITUTE OF PETROLEUM

Wed., May 3.—61, New Cavendish Street, London, W.1, "Recent Developments in Arc Welding as Applied by the Petroleum Industry," W. K. B. Marshall and V. I. Holmes, 5.30 p.m.

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

Mon. to Thurs., April 24 *to* 27.—STRESS ANALYSIS GROUP: Department of Physics, University of Southampton, Southampton, Annual Conference on "The Mechanics of Rupture."

INSTITUTE OF REFRIGERATION

Thurs., May 4.—The Institute of Marine Engineers, The Memorial Building, 76, Mark Lane, London, E.C.3, "Metals for Refrigeration and Other Low Temperature Installations," G. P. Smedley, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., April 24.—SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow Annual General Meeting, 7.30 p.m.

Tues., April 25.—NORTH EASTERN CENTRE: Three Tuns Hotel, Durham City, Annual General Meeting, 7 p.m.

Wed., April 26.—NORTHERN CENTRE: Victoria and Station Hotel, Preston, Annual General Meeting, 7.30 p.m.

Thurs., April 27.—NORTH WESTERN CENTRE: Merton Hotel, Merton Road, Bootle, Liverpool, 20, Annual General Meeting, 7.30 p.m.

INSTITUTE OF WELDING

Tues. to Fri., April 25 *to* 28.—54, Princes Gate, Exhibition Road, London, S.W.7, Spring Meeting, Theme "Recent Developments in the Welding and Allied Processes."

INSTITUTION OF AGRICULTURAL ENGINEERS

Tues., April 25.—Piccadilly Hotel, London, W.1, Annual General Meeting and One-day Conference, 10.30 a.m. and 2.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Mon., April 24.—BRITISH NUCLEAR ENERGY CONFERENCE: Grand Council Chamber, Federation of British Industries, 21, Tothill Street, London, S.W.1, "The Development of Fluid Fuel Reactors," A. M. Weinberg, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., April 25.—Great George Street, Westminster, London, S.W.1, "The Inner Ring Road, Birmingham," Sir Herbert Manzoni, 5.30 p.m.

Thurs., April 27.—TRAFFIC ENGINEERING STUDY GROUP: Great George Street, Westminster, London, S.W.1, Discussion on "Safety Aspects of Motorway Design," introduced by W. F. Adams, 5.30 p.m.

Tues., May 2.—Great George Street, Westminster, London, S.W.1, "New Tunnels near Potters Bar in the Eastern Region of British Railways," A. K. Terris and H. D. Morgan, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Sat., April 22.—LONDON GRADUATE AND STUDENT SECTION: Visit to St. Bartholomew's Hospital, High Voltage X-Ray Therapy Department, 10.30 a.m.

Mon., April 24.—EAST ANGLIAN SUB-CENTRE: Electric House, Ipswich, "A Basis for Short-Circuit Ratings for Paper-Insulated Cables up to 11kV," L. Gosland and R. G. Parr, 6.30 p.m. ★ SOUTH MIDLAND ELECTRONICS AND MEASUREMENT GROUP: James Watt Memorial Institute, Birmingham, Annual General Meeting, and "A Review of Progress in Ultrasonic Inspection Techniques," A. C. Rankin, 6 p.m. ★ LONDON GRADUATE AND STUDENT SECTION: Savoy Place, London, W.C.2, "Development of City Distribution Systems," G. W. Green, 6.30 p.m.

Tues., April 25.—NORTH-WESTERN SUPPLY GROUP: Engineers' Club, Albert Square, Manchester, "An Electrostatic Dust Monitor," D. H. Grindell, 6.15 p.m. ★ MEASUREMENT AND CONTROL SECTION: Savoy Place, London, W.C.2, "Simulation of Intelligence," D. M. Mackay, 5.30 p.m.

Wed., April 26.—ELECTRONICS AND COMMUNICATIONS SECTION: Savoy Place, London, W.C.2, "Data Transmission, R. H. Franklin and J. Rhodes, 5.30 p.m. ★ LONDON GRADUATE AND STUDENT SECTION: Visit to Ketay, Ltd., Romford, Essex, 2.30 p.m. ★ HATFIELD DISTRICT MEETING: Technical College, Hatfield, "Railway Electrification in Great Britain," D. H. McCracken, 7 p.m.

Thurs., April 27.—ORDINARY MEETING: Savoy Place, London, W.C.2, Fifty-second Kelvin Lecture, "Medical Electronics," R. F. Woolmer, 5.30 p.m.

Fri., April 28.—SOUTH MIDLAND EDUCATION DISCUSSION CIRCLE: College of Advanced Technology, Gosta Green, Birmingham, Discussion on "The Selection of Engineering Students," opened by W. D. Furneaux, 6 p.m.

Sat., April 29.—LONDON GRADUATE AND STUDENT SECTION: Visit to London Fire Brigade, Albert Embankment, London, 2.30 p.m.

Mon., May 1.—ARBORFIELD DISTRICT MEETING: Unit Cinema, 3 (Tels.) Training Bn., R.E.M.E., Arborfield, Berks., "Aural Properties of Spaced Loudspeaker Systems," J. B. Helder, 7 p.m. ★ ELECTRONICS AND COMMUNICATIONS SECTION: Savoy Place, London, W.C.2, "Progress Report on the Development of a Photo-Electric Beam Index Colour Television Tube and System," R. Graham, J. W. H. Justice and J. K. Oxenham, 5.30 p.m. ★ EAST ANGLIAN SUB-CENTRE: Assembly House, Norwich, Annual General Meeting, and "Generator/Motor Problems in Pumped-Storage Installations," J. H. Walker, 7.30 p.m. ★ SOUTH MIDLAND CENTRE: James Watt Memorial Institute, Birmingham, "Silicon Power Rectifiers," A. J. Blundell, A. E. Garside, R. G. Hibberd and I. Williams, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, April 21.—LONDON GRADUATES' SECTION: 1, Birdcage Walk, Westminster, London, S.W.1, "Lotus—The Design and Development," H. J. Lee, 6.30 p.m.

Sat., April 22.—MIDLAND GRADUATES' SECTION: Visit to Tangyes, Ltd., Smethwick, 9.45 a.m. ★ NORTHERN IRELAND GRADUATES' SECTION: Visit to Nestlés Food Products (N.I.), Ltd., Omagh, 8 a.m.

Tues., April 25.—MIDLAND BRANCH: Grosvenor Room, Hotel Leofric, Coventry, Chairman's Address, "Forty-five years of Mechanical Handling," E. Bealing, 7.15 p.m. ★ NORTHERN IRELAND BRANCH: Central Hall, College of Technology, Belfast, "Engineering Dimensional Metrology as an Aid to Engineering Production," J. Loxham, 6.45 p.m. ★ EASTERN GRADUATES' BRANCH: Town Hall, Luton, Annual Meeting, and "Review of Instrumentation in Industry," R. S. Medlock, 7.30 p.m. ★ WESTERN A.D. CENTRE: Royal Hotel, Bristol, Annual Meeting, and Crompton-Lanchester Lecture, "Electrical Equipment of the Passenger Car," E. A. Watson, 6.45 p.m.

Wed., April 26.—ORDINARY MEETING: 1, Birdcage Walk, Westminster, London, S.W.1, Annual Meeting, 6 p.m. ★ SOUTHERN GRADUATES' SECTION: Cockcroft Hall, A.E.R.E., Harwell, "Servomechanisms," C. P. Parsons, 3 p.m.

Thurs., April 27.—STEAM PLANT GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Acid Cleaning as Applied to Steam Power Plant," opened by R. F. Fisher, 6 p.m.

Fri., April 28.—WESTERN BRANCH: Royal Naval Engineering College, Manadon, Plymouth, "Hovercraft," G. J. Thomson, 7 p.m.

Sat., April 29.—EASTERN GRADUATES' SECTION: Visit to the site of the Atomic Power Station, Sizewell, 9.45 a.m.

INSTITUTION OF PLANT ENGINEERS

Mon., April 24.—WEST AND EAST YORKSHIRE BRANCH: Houldsworth School of Applied Science, The University, Leeds, "The Introduction of Planned Maintenance Systems," A. F. Stedman, 7.30 p.m.

Tues., April 25.—SOUTH WALES BRANCH: South Wales Engineers' Institute, Park Place, Cardiff, "Fuel Efficiency," W. Short, 7.30 p.m.

Wed., April 26.—LEICESTER BRANCH: Midland Hotel, Leicester, "Mechanical Handling," N. A. L. Thorne, 7.30 p.m.

Thurs., April 27.—MERSEYSIDE AND NORTH WALES BRANCH: The Blossoms, Chester, "Problems Associated with the Running of a General Engineering Works," C. J. Wright, 7.15 p.m. ★ NORTH EAST BRANCH: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Lubrication of I.C. Engines for Minimum Wear," H. Middleditch, 7 p.m. ★ SHEFFIELD AND DISTRICT BRANCH: Grand Hotel, Sheffield, "Portable and Stationary Compressors," C. A. F. Mackintosh, 7.30 p.m.

Fri., April 28.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Fire Glass Reinforced Plastics," G. O. Gurney, 7.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., April 26.—Pillar Hall, Olympia, London, 1960 George Bray Memorial Lecture, "The Protective Treatment of Metals against Corrosion," H. Silman, 4.15 p.m.

Thurs., April 27.—NORTH MIDLANDS REGION: Ruston Club, Lincoln, "Some Aspects of Production Engineering," L. R. Mumford, 7.30 p.m.

INSTITUTION OF PUBLIC HEALTH ENGINEERS

Tues., April 25.—R.S.H. CONGRESS: Jubilee Theatre, Co-operative Buildings, Coronation Street, Blackpool, "Fish, Sewage and Sea Outfalls," F. T. K. Pentelow, and "Utilising Submarine Pipeline Techniques for Sea Outfalls," W. G. G. Snook, 10 a.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Wed., April 26.—YORKSHIRE BRANCH: Metropole Hotel, King Street, Leeds, "Timber as a Structural Material," I. H. Paxton, 6.30 p.m.

Thurs., April 27.—11, Upper Belgrave Street, London, S.W.1, "Composite Construction in Theory and Practice," Konrad Sattler, 6 p.m.

Fri., April 28.—MIDLAND COUNTIES BRANCH: Byng Kendrick Suite, College of Advanced Technology, Gosta Green, Birmingham, 6, "Modern Urban Highway Structures," G. B. Smedley, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, April 21.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Informal Meeting, 7 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, April 21.—Mining Institute, Newcastle upon Tyne, "The Pametrada Hydraulic Transmission," T. W. F. Brown, P. H. Cleff and T. A. Andvig, 6.15 p.m.

REINFORCED CONCRETE ASSOCIATION

Thurs., April 27.—WEST OF ENGLAND BRANCH: New School of Engineering, The University, Bristol, "The Code of Practice for Prestressed Concrete C.P.115," A. W. Hill, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., April 25.—Library, 4, Hamilton Place, London, W.1, "On the Origin, Structure and Growth of Vortex Separations," E. C. Maskell, 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., May 1.—ORDINARY GENERAL MEETING: 12, Great George Street, Westminster, London, S.W.1, "Valuers, Quantity Surveyors and Architects—Combined Operations or Eternal Triangle?," 5.45 p.m.

ROYAL SOCIETY OF ARTS

Wed., April 26.—TRUEMAN WOOD LECTURE: John Adam Street, Adelphi, London, W.C.2, "The Training of Scientists and Engineers for Industry," Sir John Cockcroft, 2.30 p.m.

SOCIETY OF ENGINEERS

Mon., May 1.—Engineering, Marine, Welding and Nuclear Energy Exhibition, Olympia, London, "New Jet Propulsion for Boats," R. H. Bound, 5.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., April 25.—Manson House, 26, Portland Place, London, W.1, "Instrumentation in the Iron and Steel Industry," A. H. Pople, 6.30 p.m.

TELEVISION SOCIETY

To-day, April 21.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, Convention on "Television and Film Techniques."

Fri., April 28.—Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2, Annual General Meeting, 7 p.m.

Advanced Engineering Courses

Nuclear Power Plant Design. NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY, St. John Street, London, E.C.1. A short course intended to give a general survey of those sciences and technologies which are necessary in the design of nuclear power plant and to review the special problems associated with this design. The emphasis will generally be upon the nuclear powered electric generating station but mention is made of marine applications. The course runs from Monday to Friday, May 1 to 12. Fee twenty guineas.

Costing for Planning and Control. THE UNIVERSITY OF BIRMINGHAM, Institute for Engineering Production, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. A new course, to be held from Monday to Friday, May 8 to 19, presenting a background of cost accounting methods and procedures, and considering in some detail forms of cost analysis appropriate to some of the most frequently encountered problems of management. The course is intended particularly for engineers, operational research workers, production planners, industrial statisticians and managers. Fee sixty guineas.